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Index to Advertisers and Classified Index Following Reading Matter.

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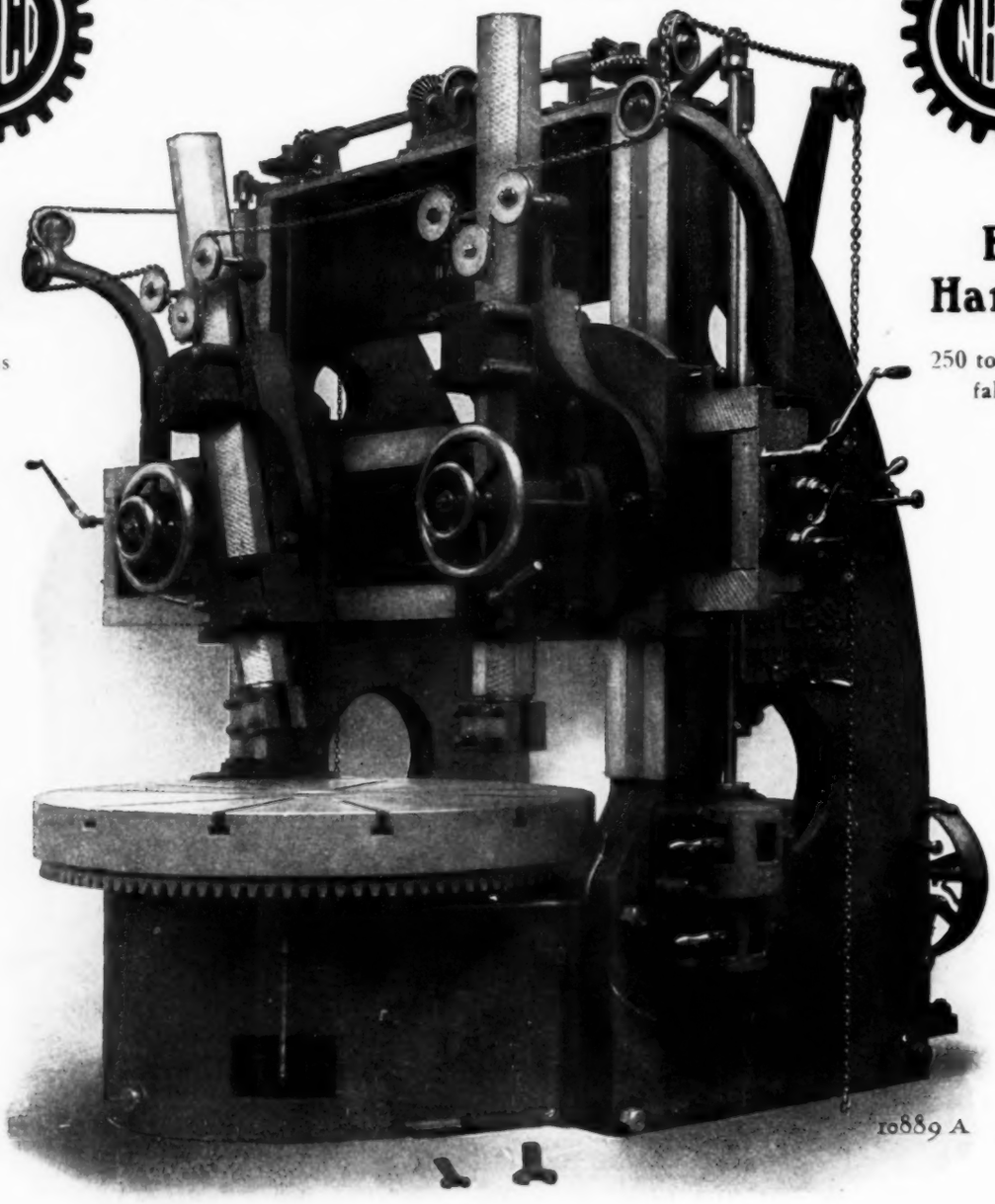

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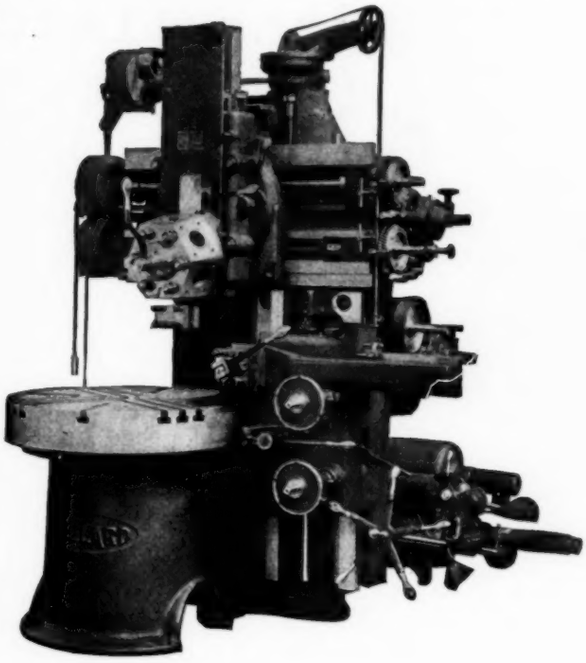

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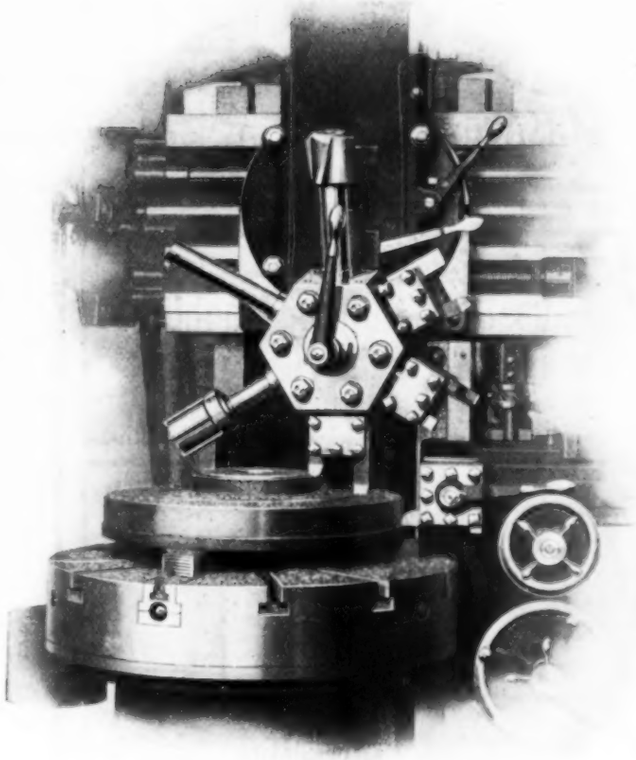

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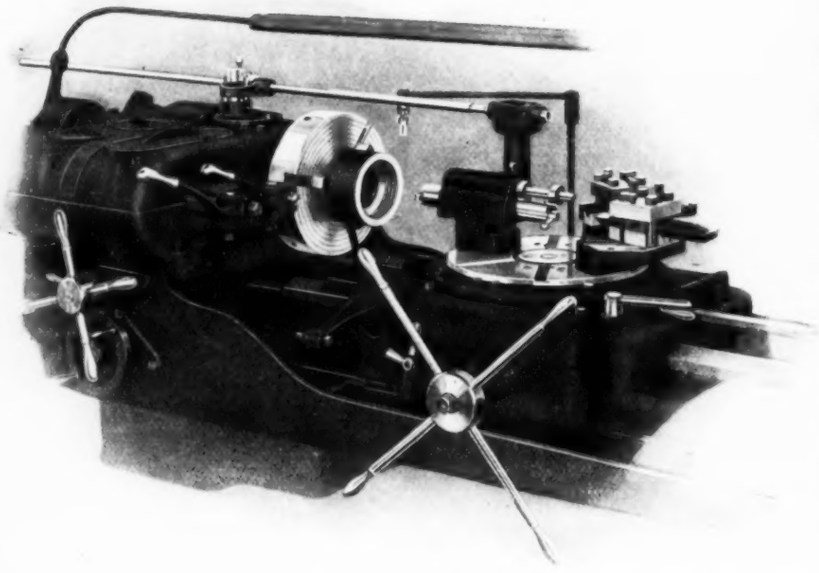

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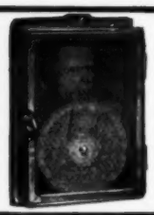

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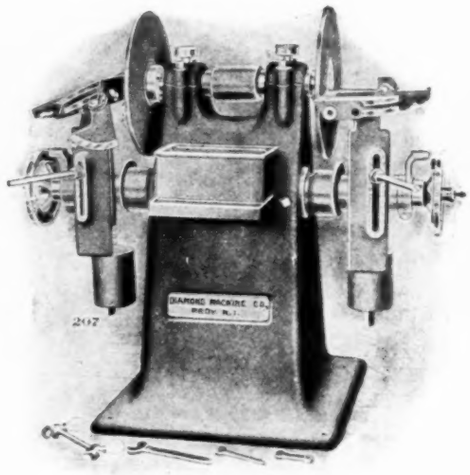

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The Microscope in the Manufacturing Plant*

How Some Important Inspecting Operations Are Carried on in a Large Establishment by the Aid of the Measuring Microscope

BY F. A. STANLEY

In a recent article several illustrations were presented showing a number of applications of the compound microscope to the work of the toolmaker. It is the purpose of the present article to illustrate some of the advantages of the microscope in connection with manufacturing processes.

The Lanston Monotype Machine Company, of Philadelphia, Penn., has for several years made extensive use of the compound microscope for facilitating the production and inspection of certain very accurate members entering into the construction of their casting machine. While there are in this machine many other parts the workmanship on which is of the finest character, the members particularly referred to here are the matrices from which the type is cast; these parts and the hardened-steel punches for sinking the characters in the matrix bodies pass in their production through some very accurate and interesting operations.

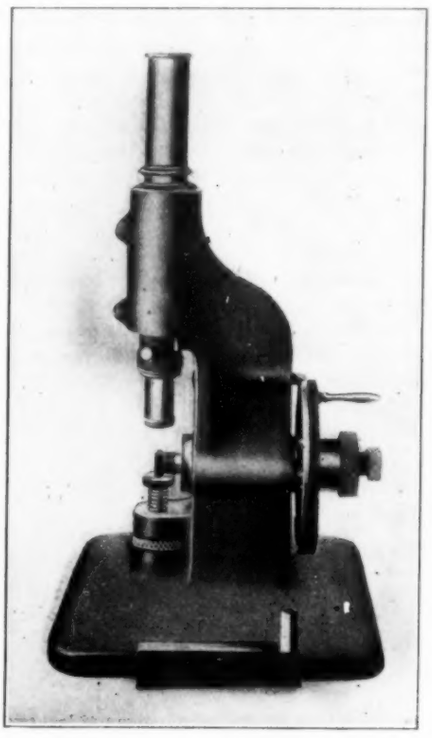


FIG. 1. MICROSCOPE WITH WORK IN PLACE

A typical microscope and its stand, as used in this establishment, are shown in Fig. 1, mounted on a bench; certain details of construction are illustrated by the line drawing, Fig. 2. In the photographic view a matrix will be noticed in position for inspection under the microscope tube.

The Monotype Matrix

The matrix is sketched in Fig. 3 about double size, the body being 2/10 inch square for type sizes from 4- to 14-point, and 15/32 inch high. The punch is sunk into the matrix (which is of hard copper) 0.065 inch in making the impression therein for the character afterward to be formed in reverse on the type. The matrices (225 in number) are carried in a matrix case in the casting machines. There are 15 rows of 15 matrices each in the case, and each row is carried upon a wire passing through holes drilled crosswise of the matrix bodies. The case may be moved horizontally in two directions at right angles, to bring any matrix into casting position over the mold. Each matrix is centered with the mold by a taper pin fitting the hole in the end of the matrix, the movement of the case being automatically controlled by a perforated paper ribbon which has been previously punched on a keyboard machine. Now in order that each character on the type when cast shall be of proper size, with each line composing the letter or other character of the correct width, and each character correctly located on the type body—not only squarely positioned thereon, but also at the right distance from the edges of the body, so that perfect alinement will be assured between all the characters—it is absolutely essential that the punches (which are really master type of hardened steel) shall be made with the greatest accuracy. The characters must be dead square in

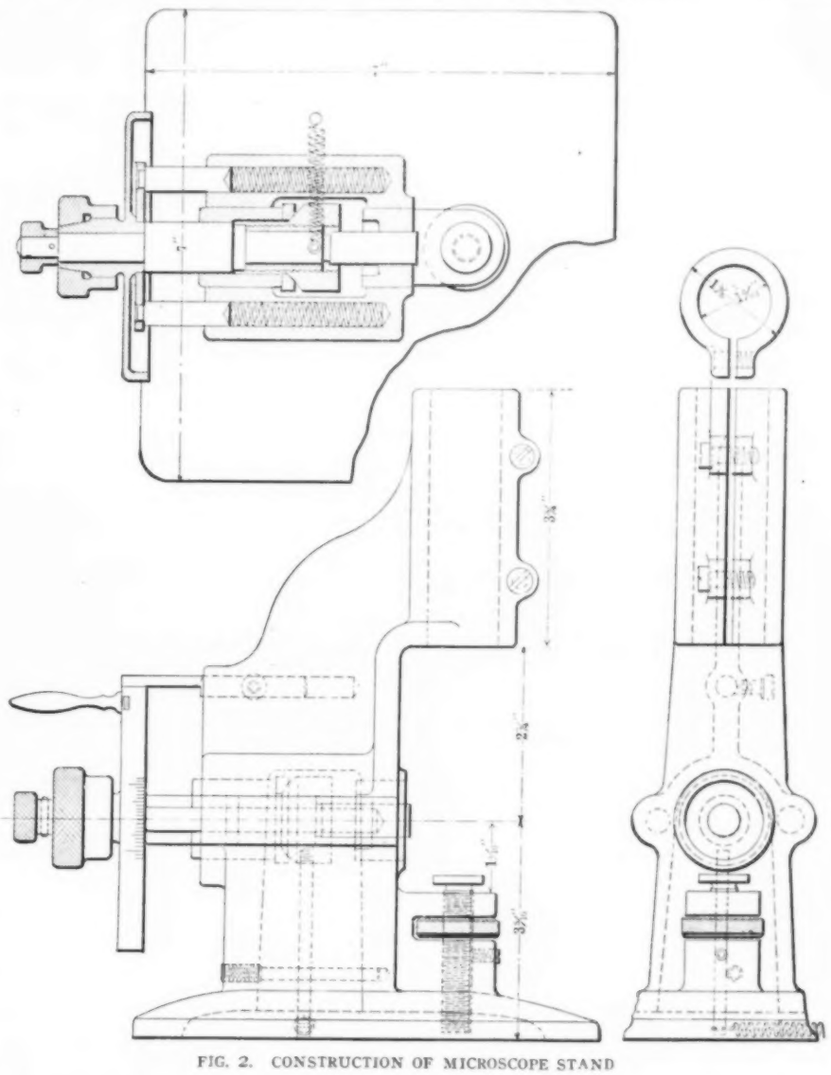


FIG. 2. CONSTRUCTION OF MICROSCOPE STAND

*Copyright, 1908, by Hill Publishing Company.

their position on the punch end, each and every line forming the character must be of the exact width desired, and the lines forming the top and bottom and the sides of the character must be at a given distance from the sides of the punch body.

Inspecting the Matrix

After the punch has been finished in an engraving machine and hardened, it is ready for sinking the impression in the copper matrix, which operation is performed in a power press. After the impression is formed, the conical centering hole is finished in the end, the hole for receiving the matrix case wire drilled through the matrix body and the copper matrix milled off to exact length and to leave the exact depth of impression required, in an ingenious special machine. The matrix is then ready for inspection under the microscope.

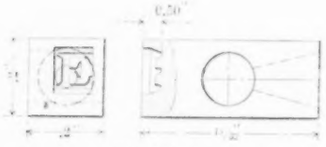


FIG. 3. MONOTYPE MATRIX

The cross hairs in the microscope are at 90 degrees to each other, as seen at *A*, Fig. 4. The test for the squareness of the base line of the character with the matrix side is indicated at *B*. *C* shows the letter as seen under the microscope with the crossbar say of a letter *H*, being tested against the cross hair of the instrument. The matrix rests, as shown in Fig. 1, on a lapped plug in the base of the instrument; one side is carried against the lapped end of a horizontal rest adjusted in and out by the micrometer screw and dial at the rear of the stand. The dial is graduated to read to ten-thousandths of an inch, and it is obvious that very minute measurements may be readily made by the combination of microscope and micrometer.

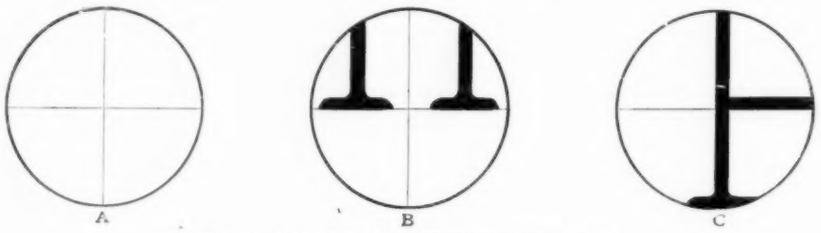


FIG. 4. USE OF THE MICROSCOPE CROSS HAIRS

The method of measuring the width of a line in the character is also indicated at *C*, Fig. 4, where one of the cross hairs of the instrument is shown coincident with the edge of the cross line in the letter. By turning the micrometer screw until the opposite edge of the line being measured coincides with the microscope cross hair, the width may be read at once from the micrometer dial.

The knife-edge square shown in front of the microscope stand in Fig. 1 is used in testing the squareness of the sides of the work with one another. This square is used quite generally in the Monotype shops and something further about its use, as well as some of the processes employed in making it, will be taken up in a succeeding article. As for the microscope stand, its construction will be sufficiently clear from the photograph and the line drawing, Fig. 2, without detailed explanation. Ordinarily, while in use, the base of the stand is covered with a piece of felt, so that if a matrix drops accidentally, there will be no risk of its being injured.

Microscope with Two Screws

Fig. 5 illustrates another microscope for matrix inspection, which has two micrometer screws at right angles to each other.

The photograph shows plainly the method of locating the matrix under this microscope, where it rests in a notch cut in a right-angle shoe, which in turn rests against the ends of the two micrometer screws. This feature is also shown in the right-hand sketch in Fig. 6.

It is obvious that with this microscope and its two screws it is an easy matter to measure the matrix impression from one side to the other, or from the top to the bottom of the character without changing the position of the work in the V-block in which it is held squarely. It is also a convenient instrument for testing the correctness of the position of the different lines of the impression relatively to the edges of the matrix body.

To illuminate the impression in the work sufficiently to allow easy manipulation under the microscope, a small magic lantern is employed, into which is dropped a regular incandescent light bulb, the reflector then lighting the work nicely. A number of illuminating devices thus arranged will be noticed in other photographs in this article. In this particular case the lantern was moved prior to the taking of the picture.

Other Microscopes in the Matrix Department

Fig. 7 shows in a striking manner the extent to which microscopes are used in connection with the production of the matrices, there being on the bench in this view at least a dozen such instruments. With the microscopes in this department the inspection of the impressions in the matrix is carried on with facility, as the method of lighting, which is clearly indi-

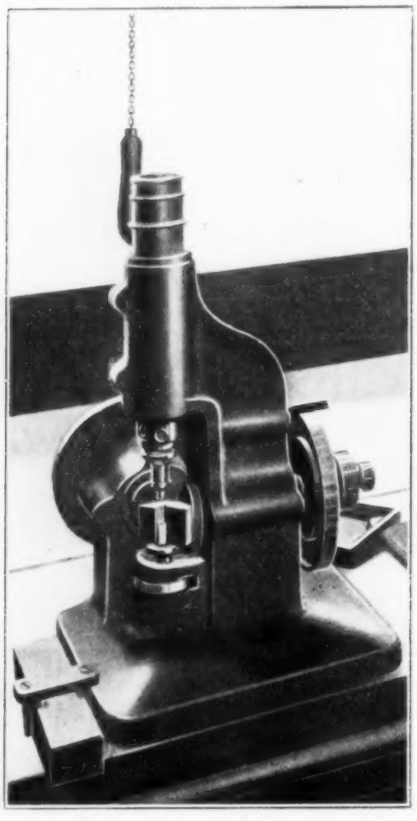
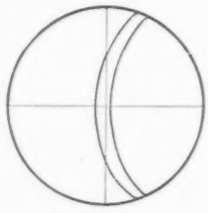


FIG. 5. MICROSCOPE WITH TWO MICROMETER SCREWS



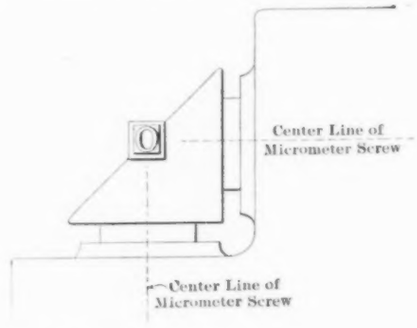


FIG. 6. PLAN OF MICROSCOPE WITH MATRIX IN POSITION

cated and which has already been referred to, enables the operator to view the bottom of the impression plainly through the microscope, as he examines the various portions of the character stamped in the matrix. As all these tests are carried along from the bottom of the impression, it is obvious that the type cast therein must be perfect on the face.

It should be stated that the row of machines shown to the right, in Fig. 7, is a part of the group of presses used in forming the matrix impression.

Another Interesting Operation

Another application of the microscope is represented in Fig. 8, which shows a special arrangement for the inspection of display matrices. The blanks in which the matrix is formed are about 1 5/32 inches long by 25/32 inch wide. The character is formed in this matrix by a special process, the details of which need not be taken up at this time.

With the display matrix, as with the other form of matrix already shown, it is important that the impression from which the type is to be cast should be square with the edges of the blank and located at a certain distance from the ends and sides. The work is placed under the microscope, Fig. 8, for inspection. The micrometer dial on this instrument like those on the other microscopes reads to 0.0001 inch, and forms a very convenient means of measuring the work accurately.

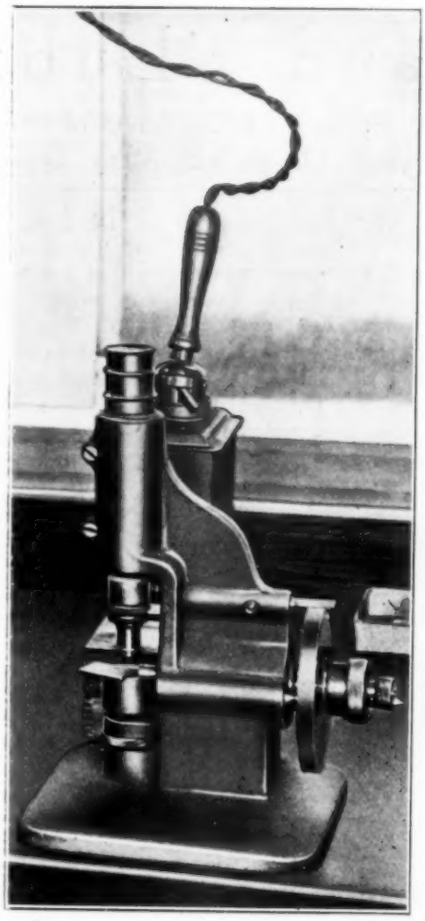


FIG. 8. MICROSCOPE FOR INSPECTING DISPLAY MATRIX

Electric Power from Wind

According to Consul-General Richard Guenther, of Frankfort, German papers state that the use of wind motors as power generators in agricultural and industrial pursuits in Denmark has increased very greatly. Since 1897 the Danish Government has contributed about $28,000 for equipments and has even lately erected an experimental station at Askoc. A technical writer describes these experiments, which were made on the initiative of the Danish Government, and also some of the electric works in Denmark which generate electricity by means of wind motors. According to his statements, motors with 4 wings have given the best results, as a smaller number of wings does not fully utilize the wind power, while a larger number acts detrimentally upon the wind current between the wings.

If a medium large wind motor is used with a wing surface of about 48 square meters (1 square meter = 10.764 square feet), 8-horse-power is obtained at a wind velocity of 6 meters per second (1 meter = 3.28 feet). At a velocity of 8 meters the horse-power is more than doubled. A wind with a velocity of 8 meters per second is no rarity. Since 1903 there has been in existence the Danish Electricity Company, from whose zealous agitation 30 larger and smaller wind-power electrical equipments are in operation throughout Denmark.

FIG. 7. ROW OF MICROSCOPES IN MATRIX DEPARTMENT

Friction and Lubrication—II

Application of the Formula for Coefficient of Friction of Lubrication to Journal Bearing Design with Many Typical Illustrations *

BY DR. J. T. NICOLSON

In endeavoring to apply the theoretical explanations and experimentally derived formulas discussed in the first section of this article beginning on page 46 to the design of a bearing what we want to know is: What is the proper proportion of length to diameter under any given conditions as to load, speed, and mode of lubrication; having regard also to the fact that the requirements demanded from the point of view of strength and stiffness must also be met.

We have to consider how much heat is generated by the viscous resistance opposed by the oil to the rotation of the shaft, in what manner this heat is dissipated, to what temperature the bearing will rise in actual running, and what law connects the temperature at which the journal may safely run with the pressure and the speed.

The heat generated is obviously equal to $\frac{\mu P \pi d N}{12 J}$ thermal units per minute, if d is the journal diameter in inches, P the load in pounds, μ the coefficient of friction, and N the number of revolutions per minute.

If the heat dissipated by radiation from the surfaces of the housing and shaft be, as usually assumed, proportional to dl, the projected bearing area, and to θ the temperature difference between bearing and external air; then, when the temperature of the bearing becomes steady, we shall have (e being the emissivity coefficient)

$$\frac{\mu P \pi d N}{12 J} = e d l \theta. \qquad (8)$$

In the standard text-books—e.g., Unwin's "Machine Design," vol. i. p. 240—it is usually assumed that whatever may be the diameter or length of the proposed journal the value of μ will remain constant. In that case

$$= \frac{\mu P \pi N}{12 J} = \frac{\mu \pi}{12 J e \theta} PN = \frac{PN}{\beta}, \qquad (9)$$

which means that the length of the bearing must increase with the load and the revolutions.

As a matter of experimental fact, however, μ is by no means constant. It depends on speed, pressure, and temperature, and, as we have already seen, we may take it to follow the law

$$\mu = \frac{1.8 \sqrt{v}}{\theta p}. \qquad (10)$$

This erroneous assumption of μ a constant, as usually made, leads to merely arbitrary determinations of journal lengths by the use of the constant β. If we consult the above text-book, we shall find that this so-called constant β varies in value from 30,000 to 1,500,000. A good deal is thus left to the taste and discrimination of the designer.

The more correct method will be to use the value for the coefficient of friction which has been determined by experiments upon bearings as above described.

If, then, we insert this value in (8), we obtain,

since $v = \frac{\pi d N}{12}$,

$$\frac{c P (\pi d N)^{\frac{3}{2}}}{12^{\frac{3}{2}} p \theta J} = e d l \theta$$

With $c = 1.8$, $\frac{P}{p} = l d$, and $J = 778$, we get

$$\theta^2 = \frac{(d N)^{\frac{3}{2}}}{3400 e}. \qquad (11)$$

To determine the value of e, the emissivity coefficient, we may apply this formula to Stribeck's results from his Sellers bearing. This bearing of diameter 2.76 inches attained—according to that figure—after running for three hours at 760 revolutions per minute, a final temperature of about 140 degrees Fahrenheit. Therefore

$$\theta = 80 \textit{ degrees Fahrenheit.}$$

Hence from

$$e = \frac{(d N)^{\frac{3}{2}}}{7 \theta^2}$$

we obtain

$$e = \frac{(2.75 \times 760)^{\frac{3}{2}}}{3400 \times 80^2} = \tfrac{1}{210} \text{ B.t.u.} \qquad (12)$$

dissipated per square inch of projected bearing area per minute per degree difference of temperature Fahrenheit, between the bearing and the outer air.

Thus the formula for θ, the final rise of temperature of a bearing above its surroundings, becomes

$$\theta = \frac{(d N)^{\frac{3}{4}}}{\sqrt{3400 \times \frac{1}{210}}} = \frac{(d N)^{\frac{3}{4}}}{\sqrt{15.6}},$$

or in round numbers

$$\theta_f = \frac{(d N)^{\frac{3}{4}}}{4}. \qquad (13)$$

Expressed in words, this means that the steady or finally attained temperature of a bearing of given diameter is higher the greater the ¾ power of the revolutions, and is greater for a given speed the larger the ¾ power of the diameter. It is, however, quite independent of the length of the journal.

We cannot, therefore, hope to lower the terminal temperature by lengthening the bearing. The heat generated increases as fast as the area for dissipating it does; for although by lengthening the journal the bearing pressure is diminished, yet since μ varies inversely as p, the frictional resistance and the heat generated are *pari passu* increased.

We know, however, from experience, that journals must be made long for high speeds, and the above conclusion seems at first sight to conflict not only with the text-books, but also with practice, and so to be paradoxical.

The explanation is as follows: While it is true that the final temperature to which a bearing will rise after a long run under a given load and with a given lubricant, depends only on the diameter of the spindle and on the speed of revolution, i.e., only on the rubbing velocity, and not at all upon the length of the journal, we have to remember that if that finally attained temperature be too high the lubricant will be squeezed out unless the bearing pressure is low.

If, referring to Stribeck's and Heimann's curves—Figs. 5 and 6—we take it that the conditions attending the minimum values of the coefficient of friction are those under which the oil begins to escape from the bearing, and that for any lower speed the bearing will run dry, we may find the connection between rubbing speed and temperature on the one hand, and rubbing speed and pressure on the other, which specifies the condition of safe running with a complete oil film.

According to Heimann's curves, Fig. 6, from experiments in which the temperature of the bearing was varied, while the bearing pressure remained the same, it appears that the coefficient of friction attains a minimum for a different value of the surface speed for each different temperature, and that the value of this speed increases proportionately to the temperature, as numerically stated on the Fahrenheit scale. In fact, if v_0 be the value of the speed for the minimum, and t the bearing's temperature, Fahrenheit, we find $v_0 = \frac{1}{2} t$.

From Stribeck's and Heimann's curves, Fig. 5, drawn from experiments in which the bearing pressure was varied, the tem-

*Abstract of a paper presented to the Manchester Association of Engineers, Manchester, England.

perature remaining unaltered, the speed for the minimum coefficient is found again to be proportional to the pressure. For Stribeck's Sellers bearing $v_o = \frac{1}{2}\ p$, and for Heimann's—solid—bushed bearing $v_o = 1/16\ p$.

Thus v_o varies as t when p is constant, and v_o varies as p when t is constant; therefore, when both t and p vary, v_o will vary as their product; or $v_o = A\,p\,t$.

The value of A in this expression is found to be different not only as between Stribeck and Heimann, but also as between Heimann's constant temperature and his constant pressure experiments.

For Stribeck's Sellers bearing we get

$$v_o = \frac{p\,t}{35}\ (\textit{constant temperature}).$$

For Heimann's bushed bearing we get

(a) For constant pressure experiments

$$v_o = \frac{p\,t}{82}.$$

(b) For constant temperature experiments

$$v_o = \frac{p\,t}{190\ to\ 240}.$$

Now, Sommerfeld has deduced mathematically an expression for this very speed for the minimum coefficient of friction, in terms of the bearing pressure, p; the radius of the journal, r; the difference between the radii of bearing and journal, δ; and the coefficient of viscosity, k.

It is of the form

$$v_o = K\,\frac{\delta^2}{r^2}\,\frac{p}{k}. \qquad (14)$$

We also found that the coefficient of viscosity for machinery oil is, for temperatures between 68 and 160 degrees Fahrenheit, well represented by the expression

$$k = \frac{c}{(t^\circ - 60^\circ)} \quad \text{or} \quad k = \frac{c}{\theta^\circ}$$

(units = pounds, feet, and degrees Fahrenheit).

Substituting for this k in (14) we obtain

$$v_o = C\,p\,\theta, \qquad (15)$$

where C is a constant, varying as the square of the ratio of the original slackness of fit to the size of the journal.

We prefer, therefore, to use the formula $v_o = C\,p\,\theta$, which has a theoretically sound basis rather than the form $v_o = A\,p\,t$, which can be made to agree with the experimental data of Stribeck and Heimann; more especially as the value of A differs so much for the different sets of curves. We ought, no doubt, to expect to find a difference for this constant as between the Sellers type of bearing used by Stribeck and the bushed bearing of Heimann, but the large variation of A in the two sets of (pressure and temperature) curves given by Heimann for the same type of bush bearing seem to point to some discrepancy, such as a considerable difference in the original amount of slackness allowed between journal and brass in the two runs.

We shall therefore, use for our purpose in designing bearings the expression $v_o = C\,p\,\theta$, with $C = 1/40$ for the value of the constant; and when written in the form

$$\theta_c = \frac{40\ v_o}{p}. \qquad (16)$$

we see that it gives the critical value θ_c of the rise of temperature, above which, under the given conditions as to surface speed (v_o feet per minute), and bearing pressure (p pounds per square inch), the oil will be in danger of leaving the bearing and allowing it to run with metallic contact of the rubbing surfaces.

What we are now proposing then is to fix the proportions of journals by reference to the minimum points of the experimental friction curves already discussed, assuming them to indicate the critical conditions as regards speed, pressure, and temperature of the bearing, below which it is unsafe to run.

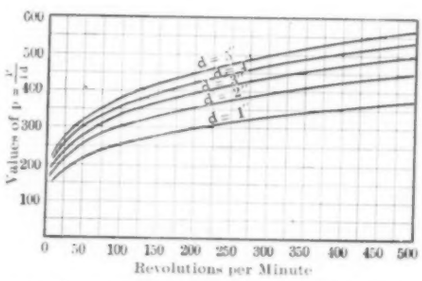


FIG. 8. ALLOWABLE UNIT JOURNAL-BEARING PRESSURES

We first calculate the terminal rise of temperature of the bearing by the expression $\theta_f = \frac{(d\,N)^{\frac{3}{4}}}{4}$. We then equate this to the value $\theta_c = \frac{40\ v}{p}$ of the above critical temperature; and so obtain a relation between the length, the load, the diameter, and the speed of revolution.

We thus have

$$\frac{(d\,N)^{\frac{3}{4}}}{4} = \frac{40\ v}{p}.$$

Substituting $\frac{\pi\,d\,N}{12}$ for v and $\frac{P}{l\,d}$ for p, we may write this

$$\frac{(d\,N)^{\frac{3}{4}}}{4} = \frac{40\,\pi\,d^2\,N\,l}{12\,P}.$$

from which we obtain

$$l = \frac{P}{40\,d^{\frac{5}{4}}\,N^{\frac{1}{4}}}. \qquad (17)$$

This is the formula proposed for use in the design of journals for speeds of rubbing up to about 450 feet per minute. It has been found to agree well with practice in all the different examples on which it has been tested. In those cases in which it does not agree, it is to be surmised that the practictioner has been misled by adherence to the erroneous theory alluded to above.

As an example of the use of the formula we may take the case of self-oiling bearings for line shafting. For ring-oiled bearings or other cases in which an abundant supply of lubricant can always be maintained between journal and brass we proceed in the following manner: The critical temperature of the bearing expressed as an excess above 60 degrees Fahrenheit is: $\theta_c = \frac{40\ v_o}{p}$; v_o being the speed feet per minute at which metallic contact is in danger of occurring under the given bearing pressure p pounds per square inch.

The finally attained temperature of the bearing of diameter d (inches) (after running, i.e., for several hours) at the speed of revolution N (revolutions per minute) is (also in excess of 60 degrees Fahrenheit)

$$\theta_f = \frac{(d\,N)^{\frac{3}{4}}}{4}.$$

For cool running, without wear, we must therefore have θ_f less than, or at most equal to,

$$\theta_c,\ i.e.,\ \frac{(d\,N)^{\frac{3}{4}}}{4} > \frac{40\ v_o}{P}$$

Now if l is the (unknown) length of the bearing and P its given load, we have $p = \frac{P}{l\,d}$. Also, if the final temperature attained is allowed to be just over the critical temperature corresponding to the given speed and load; then

$$v_o = \frac{\pi\,d\,N}{12}.$$

So that we have—

$$\frac{(d\,N)^{\frac{3}{4}}}{4} = \frac{40\,\pi\,d^2\,N\,l}{12\,P}$$

or

$$l = \frac{P}{40\,N^{\frac{1}{4}}\,d^{\frac{5}{4}}}.$$

The values of $p = \frac{P}{l\,d} = 40\,(d\,N)^{\frac{1}{4}}$, for the various cases usually occurring in practice (that is for ordinary values of d and N) have been calculated. They are shown as curves in Fig. 8.

Thus if we have a shaft 2 inches diameter running at 100 revolutions per minute the bearing pressure which must not be exceeded if a complete film is always to be maintained is by the diagram 150 pounds per square inch. Hence if the load P were 600 pounds, the length of the journal would be

$$l = \frac{P}{150\,d} = \frac{600}{150\,d} = \frac{4}{d} = 2\ inches.$$

If the load were 1200 pounds the journal would have to be 4 inches long and so on.

With the same diameter of shaft, if the speed were only 25 revolutions, the

bearing pressure allowed would be reduced to about 100 pounds, and the length would be

$$l = \frac{P}{100\,d} = \frac{600}{100\,d} = \frac{6}{d} = 3 \text{ inches}$$

for a 600-pound load.

If, on the other hand, the speed were 500 revolutions per minute, the bearing pressure might be as high as 225 pounds and the length need only be

$$l = \frac{600}{225\,d} = 1\tfrac{3}{8} \text{ inches}.$$

In other words, the allowable bearing pressure $p = \frac{P}{l\,d}$ varies between 100 pounds and 225 pounds per square inch, according to the expression, for the different speeds and diameters above indicated. It will be noticed that, contrary to the view usually accepted, the length must be greater the slower the speed.

This is clearly correct; for the slower the speed the greater difficulty has the journal in dragging in its supply of oil to meet the required demand in opposition to the bearing pressure which is squeezing it out.

The lower must that bearing pressure accordingly be; i.e., the greater l for a given d, in order to enable the journal to maintain its oil film unbroken.

Journals for Heavy Loads at Low Speeds

Another set of conditions which are frequently met and have to be dealt with in practice are those in which a journal has to run under a heavy load at a very slow speed.

What we have now to guard against is the entire collapse or tearing asunder of the film of lubricant, owing to the slow speed at which the bearing is being worked. Stribeck's and Heimann's curves of speed and pressure, at constant temperature, show that, after the minimum points are passed, as the speed still further diminishes, the coefficient of friction begins to rise very rapidly, and that, whatever the load may be, all the curves converge upon the value 0.15, the coefficient of "dry" friction for greasy metals, determined by Morin. The rate of rise of the friction curve depends on the amount of bearing pressure, being much more rapid, at all events for a Sellers bearing (see Fig. 7), for low than for high bearing pressures.

A low pressure is accompanied by a low speed for the "minimum point," and when once the tearing of the oil film begins the journal is unable to bring up a fresh supply, owing to its small surface speed. High bearing pressures have their minimum friction points at high speeds, and the journal brings up considerable quantities of oil, even when the speed has become low enough to break the film, so that the resulting friction is probably partly due to viscous resistance and partly to metallic contact.

The values of the speeds for the minimum points of the coefficient of friction curves, Figs. 5 and 6, as they depend on the bearing pressures which we used before, will now again serve as indicating the dangerous conditions to be avoided if the oil film is to remain unbroken.

The Sellers bearing gave the relation $v_1 = \frac{1}{2}\,p$, and the bushed bearing $v_0 = 1/16\,p$ for these points. If, therefore, the surface speed of the journal be v feet per minute, the bearing pressure may not exceed $2\,v$ pounds square inch for a bearing in halves, and $16\,v$ for a solid or bushed bearing, if metal-to-metal contact of journal and bearing is to be avoided.

A very commonly occurring case is that of an ordinary lathe spindle when taking its deepest cut or carrying its heaviest load at its slowest velocity of rotation. It may fairly be assumed that every lathe will at times be called upon to take a finishing cut at a speed of 18 feet per minute upon a heavy job of face-plate diameter of the greatest length the lathe can take in, and of which one-third the weight will be taken by the front journal. We obtain, therefore, the following value of load and speed (h = hight of centers):

The weight of the job assumed, $2\,h$ in diameter and $6\,h$ long, is

$$\frac{\pi}{4}\,(2\,h)^2 \times 6\,h \times 0.3 \text{ pound} = 5.66\,h^3 \text{ pounds}.$$

One-third of this will be $2\,h^3$ (and allowing for the weight of face plate, etc.), or $W = 2\,h^3$.

If the bearing be taken of diameter $\frac{h}{3}$, the rubbing speed is $\frac{18 \times h}{3 \times 2\,h} = 3$ feet per minute; and, according to the above table, the safe load is therefore from 6 to 48 pounds per square inch of projected bearing area. But the actual bearing pressure will be, if we assume the usual value $\frac{h}{2}$ for the length of the journal

$$p = \frac{2\,h^3}{\frac{h}{2} \times \frac{h}{3}} = 12\,h;$$

i.e., 120 pounds per square inch for a 10-inch and 600 pounds per square inch for a 50-inch lathe.

We see, therefore, that it is impossible to give the large dimensions to the front bearing that would be necessary to prevent the oil film from being broken at such slow speeds; and, as a matter of fact, lathe spindles turning at the slow speeds used for heavy cuts inevitably run metal-to-metal with their brasses, giving rise to the high frictional resistance corresponding to the coefficient of friction of 0.15 for greasy metals.

The work thus spent and wasted on friction and wear may, as worked out above, amount from 2 to 10 per cent. of the total useful work expended on cutting. From ¼ to 9 (according to size) horse-power is, therefore, wasted on the friction of the front journal alone when the lathe is running at these slow rates with a heavy job between centers.

Even if the job be light, and the thrust on the front journal that due to the standard cut only, it can be shown that 2½ per cent. of the useful work is spent on friction on any size of lathe when the speeds are so low as to squeeze out the oil film.

We are here face to face with a very serious loss of power, and a correspondingly large amount of wear of the spindle and brasses in the front bearing, not at all due to high speeds of rotation of the spindle; and it is owing to this that the elaborate arrangements for adjustment of the spindle in a lathe headstock have to be provided.

It is impossible to give enough area in the front bearing of a lathe headstock to prevent metallic contact of journal and brass at the slower speeds, if dependence is placed upon the lubricant being carried in by the ordinary action of the shaft's rotation, the supply being automatic.

By using a force pump, however, and

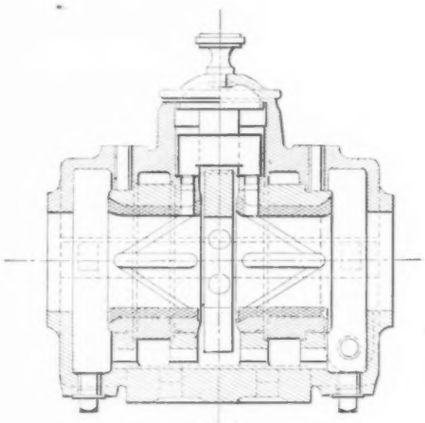


FIG. 9

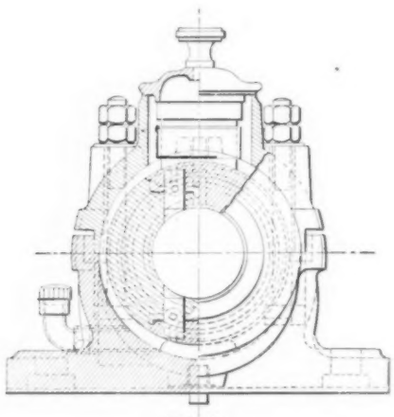


FIG. 10

AN EXAMPLE OF FAST COLLAR LUBRICATION

injecting a stream of moderately heavy oil into the bearing at the place where the pressure is greatest, it is possible to raise the journal off the brass even when at rest, and to keep it floating with a film of oil interposed between itself and the bearing when in motion, be that motion as slow and the load as high as it may.

If metal-to-metal contact can in this way be prevented at slow, and by the ordinary methods at high speeds, there seems to be a possibility that wear may be entirely eliminated. If this be so, it follows that adjustments for wear are unnecessary, and instead of the elaborate and expensive designs of front and back bearings which are now used we may expect that a simple solid bushing of ample thickness, and of a length not greater than $2\sqrt{h}$, as indicated above, will meet every requirement.

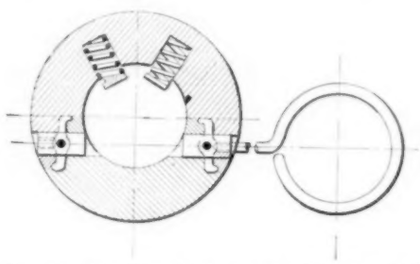


FIG. 11. DETAIL OF RING IN BEARING SHOWN IN FIGS. 9 AND 10

Such a solid bushing of hard bronze round the steel spindle has a great deal to recommend it from the point of view of accuracy of fit, solidity, and stiffness, as compared with the intricate methods of adjustment which are now common.

Illustrative Examples

The chief distinction between the modern and the older methods of lubricating bearings lies in the fact that the oil is no longer supplied drop by drop as formerly, but in an abundant stream. The rubbing surfaces are, so to speak, drenched by it, and the heat generated by the viscosity of the shearing oil film is carried away before it can accumulate and give rise to a dangerously high temperature in the bearing. The oil not only lubricates, but cools the journal, and, notwithstanding its abundant supply, very little may be really used.

The endeavor has been also to make the lubrication quite independent of attendant labor, in order to obtain reliability of action. Hence the so-called "self-oiling" bearings.

For high-speed bearings the principle most usually adopted is that of the closed circuit. The oil, as thus the name implies, is used over and over again. After dropping off the journal into a collecting reservoir it is filtered and used anew, being automatically supplied to the journal at a suitable point. A cooling arrangement is sometimes fitted among the oil in the reservoir, so as to remove the heat from heavily loaded bearings.

In many cases the system of forced lubrication has been adopted. The oil is then, by means of a pump or other suitable means, pressed in between the rubbing surfaces, so that the journal floats on a thick film of lubricant.

Horizontal Bearings

The best known "closed cycle" method of lubrication of horizontal journals is the ring-oiled bearing. By means of a loose ring which rests upon the shaft, turns with it, and dips in the oil reservoir at its lower side, the oil is brought up to the top surface of the journal, and flows over it through the oilways. A broad ring, flat inside, and rounded on the outside, is the best form. If the edges of the bearing next the ring are turned and the oil be not allowed to become viscid by old age, such a form of ring will seldom stick.

No ribs or other projections should be fitted on the rings, otherwise the resistance produced by their passage through the oil bath brings them to rest. At high speeds the ribs carry down air into the oil bath. Bubbles are formed, the oil is made into foam, and the bursting of the air bubbles at the edges of the bearings spreads oil all over the shaft and machine. Oxidation of the oil is also accelerated by foaming. At low speeds the ribbed ring may be of service, but for high speeds smooth rings are best.

The theory of the action of the oiling ring (whether fast or loose) depends upon cohesion, capillarity, and centrifugal force. It is very complicated. At high speeds centrifugal force renders the flow of oil from ring to journal difficult, and scrapers have to be used, which divert the oil into the oilways. They must not touch the ring, or its motion will be stopped.

To prevent the oil from leaking out of the housing the upper and lower halves must make a tight joint along the sides; while spreading along the shaft is prevented by fly-rings, at the sharp outer edges of which centrifugal force overcomes adhesion, and the oil flies off and, running down the housing, returns to the well. Spring-scrapers may alternately be used if the fly-rings cannot be fitted for constructional reasons.

Deep feathers dipping into the well are fitted in good modern bearings, so the returned oil has a long distance to travel before again flowing over the journal. The slow rise in the wide space between the ribs also allows dirty particles time to fall to the bottom of the reservoir, and the ring rotates in clean, cool oil.

Self-oiling by means of rings fast on the shaft is not much used. The fast ring cannot stick, but it requires a longer design of bearing. The ring may either act also as a collar where endwise motion is to be prevented; but as such motion is usually an advantage it should be attached by a spline only.

For high speeds the scraper can, of course, be used with fast rings to overcome centrifugal force. Figs. 9, 10 and 11 show an example of fast-collar lubrication.

Vertical journals are much more difficult to lubricate than horizontal, for obvious reasons.

Forced Lubrication

By the use of a pump to force the oil drawn from a reservoir into the bearing near the point of maximum pressure the length of the bearing can be very much diminished, even for the slowest speeds, especially for journals whose load and rotation directions do not change.

The rules for design above indicated no longer hold good. The finally attained temperature of the bearing will, perhaps, not be much affected by the mechanical feeding in of the oil near the place of highest pressure; but there is no longer any question of a critical velocity depending on that final temperature and the given bearing pressure. For, even with the heaviest loads and slowest speeds, the pump will always avail to preserve a film of oil between shaft and bearing at the point of nearest approach. The length of the bearing is now governed only by the necessity of avoiding the escape of the oil from the ends of the bearing and forcing it to pass round and through the place of maximum pressure.

In all probability the length need not be more than equal to the diameter; and, if this be so, it means that the use of such

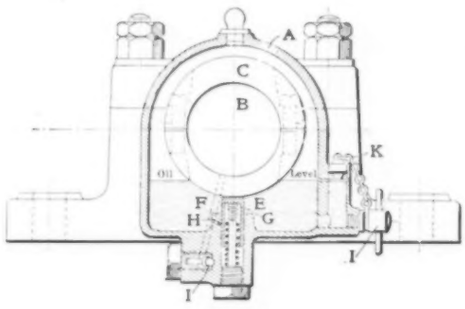


FIG. 12

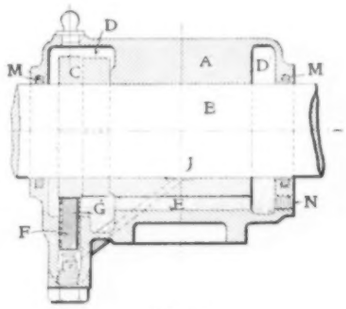


FIG. 13

A BEARING ARRANGEMENT FOR FORCED LUBRICATION

bearings implies the possibility of reducing the friction of the line shafts by about two-thirds of its present amount.

The annexed Figs. 12 and 13 show such an arrangement where, however—probably for sentimental reasons—the bearing is two diameters long.

On the shaft is placed an eccentric collar *C*. *D* and *D*¹ are end chambers to contain the oil; *E* is a passage to connect the end chambers together; *F* is a pump plunger or thimble, made from steel tubing forced on to a solid end; *G* are inlet holes in the plunger for oil to pass to the inside of the pump; *H* is a spring to keep the plunger against the eccentric; *I* is a non-return ball valve; and *J* an outlet from the pump to the shaft; *L* is a screwed plug to drain off spent oil and dirt; and *M* are leather washers to prevent the oil traveling along the shaft; *N* is a screwed plug for drilling and cleaning the passage *E*. The pump plunger or thimble *F* is reciprocated by the rotation of the eccentric. When the plunger *F* is at the top of its stroke, the oil in the end chamber *D* escapes through the inlet holes *G* inside the pump. As the plunger descends the inlet holes *G* are cut off by the casting, and thus the oil is forced past the non-return valve *I*, and through the outlet *J* to the shaft.

With such a bearing there ought to be no wear at all, except that due to the absence of an oil film at starting up. The method of forcing oil into bearings by means of a pump is now extensively used in quick-revolution steam engines and gas engines.

Tools for Making Garden Rakes

By Julius F. A. Vogt

The sketches below show a set of tools for making garden rakes of sheet steel

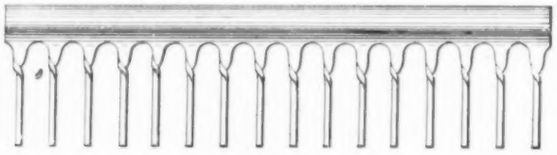


FIG. 1

FIG. 2

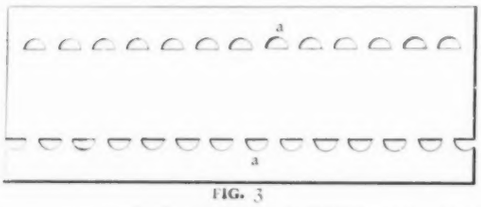


FIG. 3

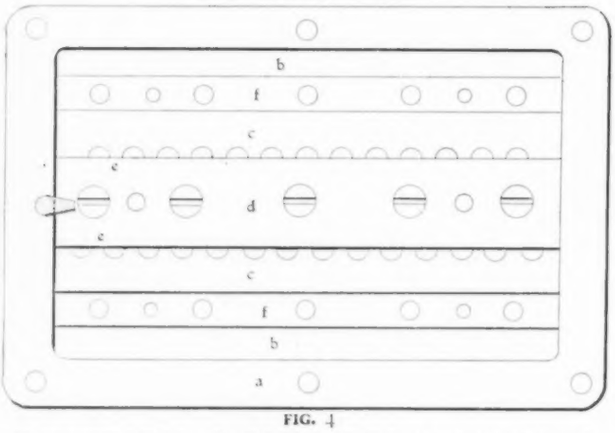


FIG. 4

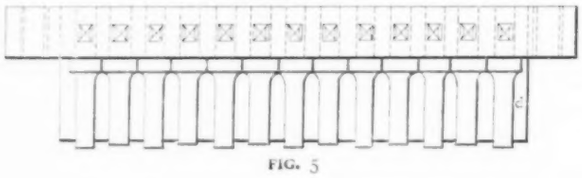


FIG. 5

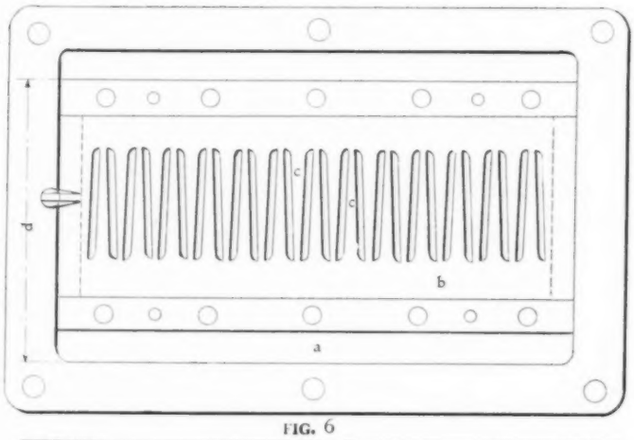


FIG. 6

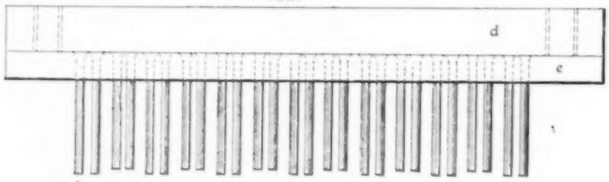


FIG. 7

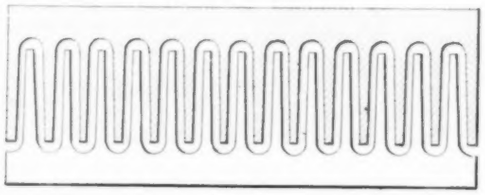


FIG. 8

SHEET-METAL RAKES AND DIES FOR MAKING THEM

bearings implies the possibility of reducing the friction of the line shafts by about two-thirds of its present amount.

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Tools for Making Garden Rakes

By Julius F. A. Vogt

The sketches below show a set of tools for making garden rakes of sheet steel 9/64-inch thick. Figs. 1 and 2 show the finished rake as produced with the tools. The dies were made for 16-tooth rakes, but shorter ones could be made by simply cutting a shorter blank. Two rakes are cut from one blank by cutting the teeth of one rake between the teeth of the other.

Fig. 3 shows a blank on which the first operation had been made. The half-round holes *a a* in this blank form with the circular part the arch between the upper part of the teeth; the straight side of the half-round hole forms the end of the teeth. These blanks were sheared to proper size and were then perforated by means of the perforating die, Fig. 4.

The Perforating Die

The die consists of the cast-iron die bed *a* with two ribs *b b*. The bottom and the space between the ribs were planed and the two steel pieces *c c*, planed to proper size, were screwed on to the die bed. A piece of machine steel planed to fit between the pieces *c c* was driven in and fastened to the bed. The half-round holes were then marked, putting the center of the radius on lines *e e*. The holes were then drilled and reamed 1½ inches taper from the bottom of the die. The machine-steel piece was then removed and the tool-steel piece *d* fitted in place of it, to make the holes half round. Pieces *c c* and *d* were then hardened and tempered; *c c* and the machine-steel piece which was used for drilling and reaming were put into the die, and we were ready to mark the punches.

The punch plate, Fig. 5, was clamped to the die, and the holes transferred to the

punch plate by means of a suitable center drill. The punch holes were then drilled and reamed, and holes for the set-screws, for holding the perforating punches, were drilled and tapped.

The perforating punches were then turned to fit snugly into the punch plate, and the cutting part to fit the die. The punches were fastened in the punch holder by means of set-screws, the point of the set-screw being let into the shanks of the perforating punches, to prevent them from turning. The punches, still being round, were fitted into the die.

After this was done, the punch plate with the punches was put into the shaper and planed off to the center to make them half round. The machine-steel piece was now removed from the die, and the steel piece *d* was put into its place and fastened. The flat side of the punches was then fitted, the shear put on the punches, and then they were hardened and tempered. The punch was then assembled. The box gages shown on the die, Fig. 4, and a stripper, not shown, were made and the die was ready to perforate the blanks as shown in Fig. 3.

Fig. 8 shows the blank, Fig. 3, separated into two rakes. This operation is done in the die, Fig. 6.

Separating the Rakes

The die bed *a*, Fig. 6, was made of cast iron, and the cutting die of tool steel welded to wrought iron 1¾ inches thick. The slots *c c c c* were laid out to conform with the half-round holes in Fig. 4. The slots were drilled and broached to as near proper size as possible and filed to 1½ degree taper toward the bottom. The die was then hardened and tempered.

The punch, Fig. 7, consists of the punch holder *d*, the pad *e* and the separating punches *f*. The pad was clamped to the die, and the slots were marked and drilled as close as possible. A punch was then made and fitted into the die from below, giving the punch the same taper as the die and extending the punch about 1/16 inch above the cutting edge of the die. The die and pad were then clamped together and put under the press with the pad down. The punch was then inserted and forced into the pad about 1/16 inch deep, one slot after the other. After this the slots for the punches were drifted and filed out to correspond with the die. The punch slots in the stripper were treated in the same manner.

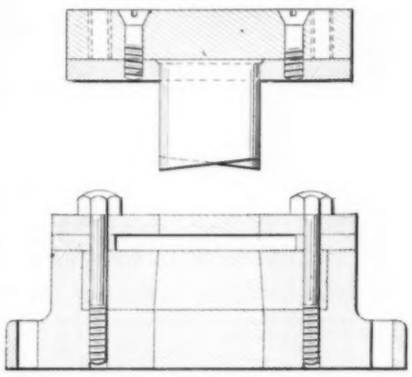


FIG. 9 Section through d-e Fig. 6

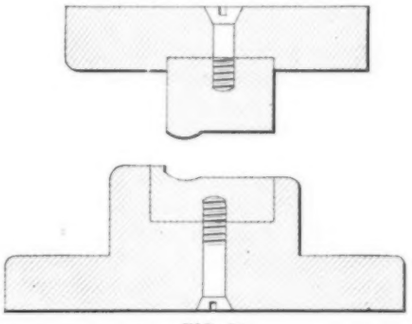


FIG. 10

PUNCHES AND DIES FOR SHEET-METAL RAKES

The punches were planed up several in one piece and then cut to proper length. The two end punches were fitted first, leaving them about ¼ inch longer than the rest. This was done to have a guide for fitting the rest of the punches. The punches were then headed as shown in the sketch. Considerable shear was given to the punches, as shown in Fig. 7 and also in Fig. 9, which is a section through *a b* of Fig. 6.

This die had a cutting edge of about 60 inches through 9/64-inch steel, or about 8½ inches through 1-inch steel. Looking at Figs. 7 and 9, it will be seen that the shearing of the punches as applied in this case required about half the pressure, taking into consideration that the separating punches started to cut in the half-round holes previously punched in the die, Fig. 4.

The next operation was to curve or bead the top part of the rakes to stiffen it. The die and punch for this work are shown in Fig. 10, showing an end elevation of the die and punch.

Twisting the Teeth

The teeth of the rakes were twisted near the arch to give them more stiffness. For this purpose the tool, Fig. 10, was designed. This shows the elevation and Fig. 11 the plan of the machine. Fig. 12 shows one of the slotted gear shafts which did the twisting. The bed plate *a* and the upper part *b* are made of cast iron, planed and bolted together by 10 ⅝-inch cap screws *c*.

The sixteen geared steel shafts *d d* were located in the machine as shown in Figs. 11 and 12, to conform with the centers of the teeth of the rake. In order to turn the teeth of the rake all in the same direc-

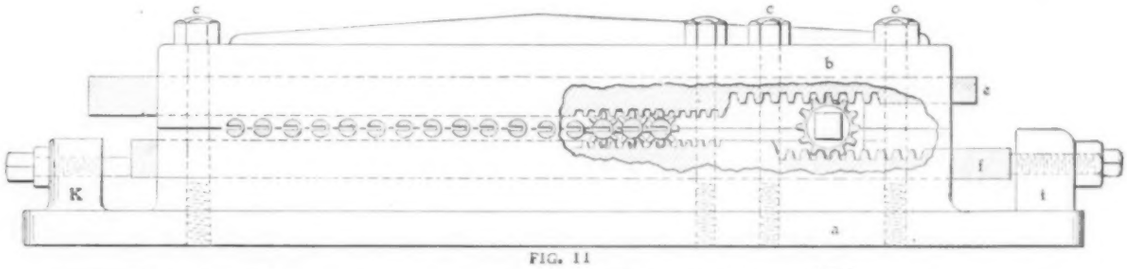


FIG. 11

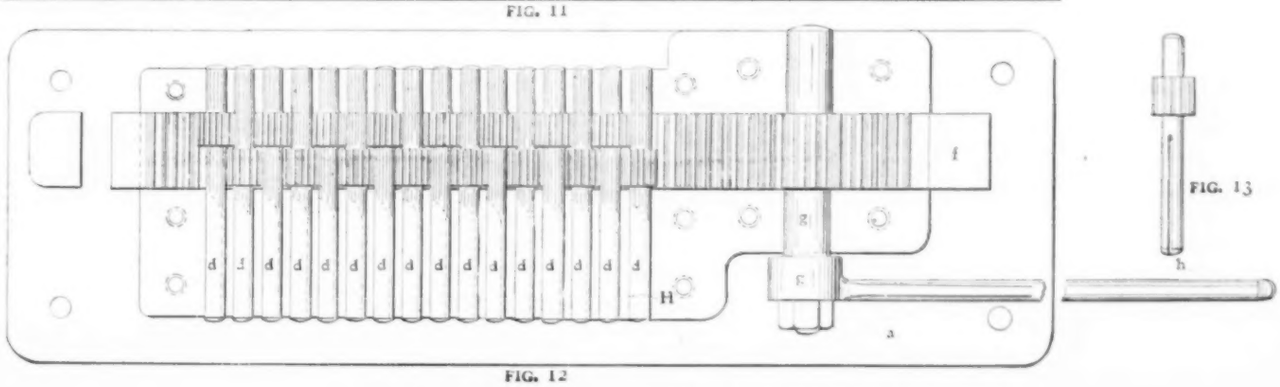


FIG. 13

FIG. 12

MACHINE FOR TWISTING THE TEETH OF SHEET-METAL RAKES

tion, the upper rack *e* and the lower rack *f* were made double the width of the gears and the gear shaft ends toward the back of the machine were made longer. See Fig. 12. The gear shafts and the rake were cut to fit so that there was no lost motion. The racks *e* and *f* are driven by the larger gear and lever shaft *g*. This part of the rack was cut to conform with the gear on the shaft *g*, which is twice as large as the small gears.

After the gear shafts were fitted to revolve nicely, the lever was put at an angle of 45 degrees, and the slots in the gear shafts were marked to get them all in a horizontal position. Then the shafts were taken and numbered, and the slots *h*, as shown in Fig. 13, were milled in. The gear shafts were then hardened and tempered, and the machine was assembled.

The lever *g* is thrown to the left until the lower rack *f* stops against *i*. The teeth of the rake are put into the slots *h*, in the pinion shaft; the lever *g* is then pulled to the right, until the rack *e* stops against *k*. This motion gives a twist of 90 degrees to every tooth in the rake. The rake is then extracted from the machine and the lever *g* is returned to its former position to receive another rake. The rakes made with these tools were very strong and were cheaply made.

A Few Locomotive Tools and Fixtures

Ways in Which Time and Money Can Be Saved by Using Special Appliances on Railroad Work When Made in Quantity

BY L. E. SALMON

Believing that some of the tools and makeshifts used in a locomotive shop where comparatively cheap yet efficient tools are required to do a great variety of work in the least possible time and with, very often, unskilled help would be interesting to a number of your readers, I give some from my own shop experience.

As is very often the case in a locomotive plant, a tool designed to machine any one part of an engine must be made with a wide range of usefulness, owing to the fact that the styles of different types of engines vary so much that any one part, although performing the same function, may have a great number of styles, shapes and sizes as specified by different railroads. Therefore when the foreman toolmaker designs a new tool or fixture, it is very often necessary for him to look over all the drawings of the particular part in the shop he is making the tool for; if he cannot make the tool adaptable to them all, he must so design it that it can be used to the greatest possible advantage on the most common type or types of engines. Such was the case with the rocker-box tools here shown.

In Fig. 1 is shown the style of rocker box that was running through the shop at the time this particular tool was designed. As will be noticed, this particular box was required to be turned on the outside of the ends to 5½ inches diameter 3⅛ inches up (there are a great many rocker boxes that are not touched on the outside at all), faced off as usual, bored to 4 inches inside, with a ¼-inch radius on each end of the hole, and of course planed for the seat on the frame and the two faces where they are bolted together.

These boxes are first planed, drilled and bolted together; they are then placed on what might be called a tongue parallel, which is set square on the platen of the boring mill and bolted securely. The tongue of this parallel is a nice fit in the frame slot of the rocker box; on it the rocker box is bolted or clamped firmly, thus securing a hole in perfect square to the slot. I became convinced that a properly made reamer would follow the first or roughing cutter just as well as, if not better than, it would go through alone, providing they were both mounted on a suitable bar, thereby boring and finishing the hole in one cut. So I made a "cat head" to carry four tools, two for the outside turning and placed opposite each other, with a facing tool and an inside radius tool. We could then perform all operations on one end in one cut. By setting these tools according to the dimensions required, each one in proper relation to the other, the result was a finished end in the time it had previously taken to take only one chip off the outside, and it also eliminated all extra changes of cutters.

The bar is shown in Fig. 2, made of 2⅝-inch round machine steel turned down to 2½ inches diameter, with a slot for the roughing cutter, Fig. 8, which was held in the ordinary manner by a taper key. A flat, ¾ inch wide, was then planed on each end for the set-screws of the two cat heads to seat upon and also for the finishing reamer; these screws were to stop any shifting or sliding of the above named parts. The driving was done by two ⅜-inch keys on opposite sides, making a very rigid and positive drive.

The reamer construction is plainly shown by the sketch, Fig. 6. The tapped hole is for the set-screw to hold it on the bar, this screw coming below the cutting edge of the reamer.

Fig. 5 puts the radius in the hole and is made of 1¼-inch square tool steel, machined to proper shape on one end for doing its work. There are two of these, one for each cat head; they are made right and left respectively, as are the outside turning tools, Fig. 7. Four of these are required, it being necessary to have two of these in each head, one opposite the other to avoid undue jumping of the bar, which would cause the facing tool, Fig. 9, and the radius tools, Fig. 5, to chatter and leave a rough surface.

In Fig. 3 is shown a view of one of the cat heads with the four tools set in position. There were two of these, one for each end of the bar, the reason for having the cutting tools made right and left being to avoid reversing the machine.

Referring to Fig. 2, we have a general view of the bar and tools in position for machining a rocker box *a*, which is shown in cross-section. The reamer *b* has just passed out of the hole and the first cat head *c* is feeding up to the box. The two turning tools *d d* will turn the outside of the end; when they have turned up 2⅞ inches, the radius tool *e* will commence to cut; when that tool has formed a full radius, the facing tool *f* comes into play. At this point all four tools are cutting and continue until the operator finds by measuring that he has the length required from the center of the frame slot. Then he throws out his feed, runs the whole bar back through the box until the reamer is out of the hole, when the other cat head *c'* comes into action and turns and finishes this end the same as the other. By use of this tool or tools a great deal of time was saved both in actual cutting time and also in time that would otherwise be consumed in changing cutters, which counts up very quickly in a day's work.

My records tell me that it took 23 minutes to bore and ream the hole, counting from the moment the roughing cutter began to cut to the moment the reamer had done cutting, and an average of 13 minutes for doing each end, making a total of 49 minutes for doing all the boring, turning, facing, reaming and putting the radius on each end of the hole. These boxes were tested in every way by plugs and gages and were up to standard in every respect.

After one box was finished, the first cat head *c*, the reamer *b* and the cutter *g* were removed. The cat head *c'* on the tail end of the bar was loosened, but not

taken off, and the bar slid out through the back support far enough to allow of the finished rocker box being removed and another placed on the machine. When this was done, the bar was pushed back through the box, the cutter, reamer and cat head replaced, then keyed into the spindle, and we were ready to commence all over again. All this consumed about 10 minutes average time.

Fixture for Grinding Ball Reamers

In Fig. 10 is a fixture for grinding radius tools such as semi-spherical reamers, commonly called "ball reamers," of which there are a great many of all sizes and styles used in a locomotive shop, such as for steam-pipe joints. It can also be used for grinding round corners on cutters. The cutter shown set up is a paneling cutter, used to panel or recess the connecting-rods, and has a radius of ⅜ inch. Some have ¼-inch radius; but this is apt to vary, some railroads calling for a small radius and others calling for larger ones.

This fixture was designed to do away with that time-honored practice of stringing a cutter to the ceiling and holding it up to an emery wheel by hand, tipping to make an apology for a round corner, the radii of the various teeth being left entirely to a man's eye and varying accordingly. By means of this fixture, every tooth can be ground accurately and quickly.

As shown in Fig. 10, it consists of an upright *A*, movable on slide *B*, which in turn is movable on slide *E*. The two slides being at right angles to each other, provide for any radius from nothing to the limit of the fixture, either directly as in the case of a ball reamer, or indirectly as with the corner of the tooth of the milling cutter, where the center of the radius to be ground is outside of the axis of the cutter.

In the latter case it is necessary to use the two slides in order to get the required center of radius, while in the former, the slide *B* is brought central in relation to the pivot and locked by means of gib *F*. The illustration shows it in this position, and it is merely a matter of adjusting the one slide or upright *A* to swing whatever radius is desired.

In order to grind all the various ball reamers in the shop, it was necessary to have a variety of different-sized studs to fit them and the hole in the upright; these were made as required. For grinding cutters, only one stud, Fig. 17, is necessary, the part *a* being a nice running fit in the upright, the other end *b* fitting the ordinary reducing bushings used for plain grinding. The cutter is held firmly on this end of the stud by pressure exerted by means of a cap bolt screwing into the end of the stud, as shown.

Figs. 11 and 12 are the upright and base respectively, made of cast iron. Fig. 13 is the feed screw of machine steel, two being used, one 4½ inches long and one 6½ inches long, as called for.

Figs. 14 and 15 are the slides or ways, the recess *c*, Fig. 15, being for the brass nut, Fig. 16. One of these nuts goes into a similar recess in the upright.

Fig. 18 is a machine-steel plate which is screwed on to the slides by means of ⅜-inch screws, as shown, to form a bearing for the feed screws, on the end of which a nurled knob, Fig. 19, is driven lightly and pinned by a taper pin, as shown in an assembling view, Fig. 10.

The pivot stud, shown in Fig. 20, is a nice running fit on the two shoulders *d d'* in the recess *d d'* respectively of the base, Fig. 12. The part *e* is a tight fit in *e'* of Fig. 14 and is held in place by a screw and dowel pin, as shown.

This fixture was clamped on a piece of boiler plate, planed flat on the two sides and screwed to the bench which carried the emery wheel, there being two elongated holes ⅞ inch wide cut through the plate and bench for the clamping bolts. The outer edge of the plate was bent up to form a flange through which a common bolt went to move the fixture up to the wheel to get the size of cut wanted.

The various teeth of the cutter or reamers to be ground are brought to proper position by use of a spring finger, as shown in Fig. 21, in plate *f* on top of the upright, as in Fig. 10.

A few samples of work ground on this fixture are shown in Figs. 22 to 26 and give a fair idea of the kind of work that can be done.

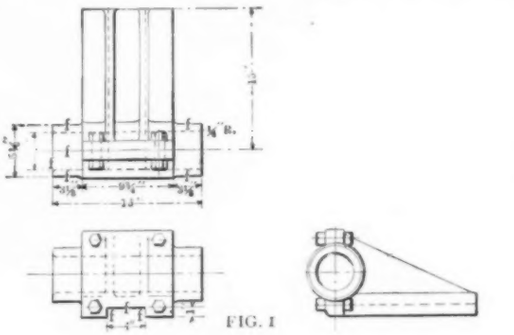


FIG. 1

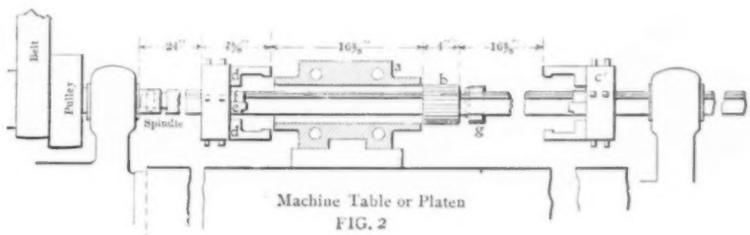


FIG. 2

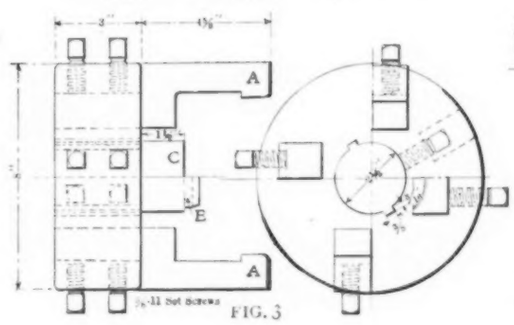


FIG. 3

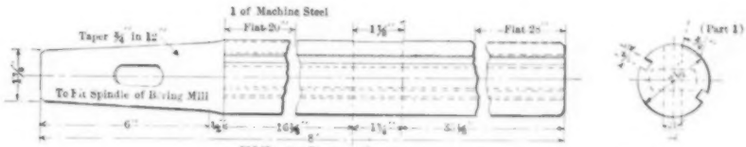
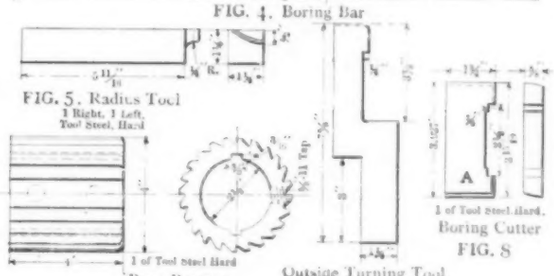
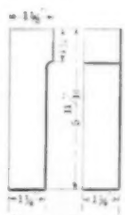


FIG. 4. Boring Bar



1 of Tool Steel Hard.
Boring Cutter
FIG. 8


Facing Cutter
1 Right & 1 Left
Tool Steel Hard.
FIG. 9

1 of Tool Steel Hard
Rose Reamer
FIG. 6

Outside Turning Tool
2 Right, 2 Left, Tool Steel Hard.
FIG. 7

TOOLS FOR LOCOMOTIVE ROCKER ARMS

Cat Heads for Hub Work

One of the most useful yet common tools of the locomotive shop is the cat head; although it is so common in this work, it is seldom seen in the ordinary machine shop. There are many good, all-round machinists who have never heard of such a tool, owing to having been in other lines of the trade.

A cat head is practically a tool for turning hubs on work which it is not practical or is impossible to put in a lathe, such as oil cups on locomotive connecting-rods, the hub or hubs on link hangers, hubs of valve rods, transmission bars or any work which is big and unwieldly. Such pieces are securely strapped to the drill-press or boring-mill platen, the hole first drilled and reamed; then the hub is turned by means of the cat head, a guide made of a wrought-iron forging, finished as shown, bored tapered to fit the shank end of pilot *A* and forced up tight by means of nut *B*. It is also held from turning by the key shown. The pilot *A* is usually made about 1 inch to 1¼ inches diameter, thus enabling it to be used on almost any sized hole simply by means of various-sized bushings.

The prime features of this style are the small amount of machine work required, piece, as shown, with the exception of the retaining ring *D*, which is a separate forging. It will be noticed that each of the four slots *a a a a* is a different distance from the center. This is to get various sizes, any intermediate size being obtained by shimming. If a larger size than the head is wanted, it is then necessary to resort to offset cutters. The cutter *E*, shown in the sketch, is an ordinary straight cutter.

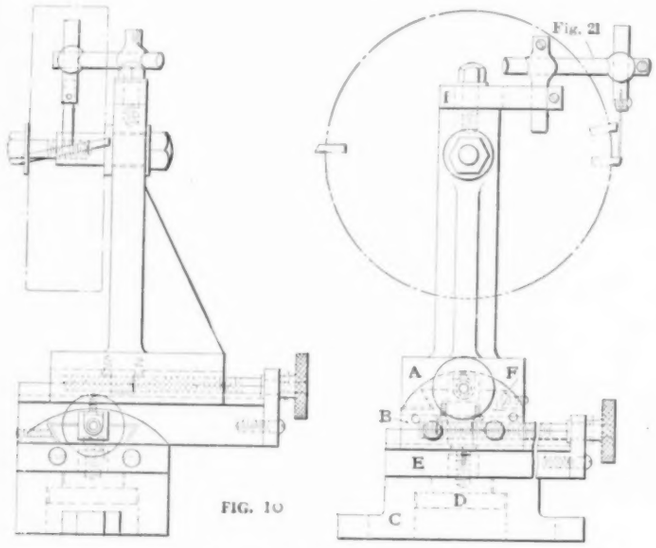
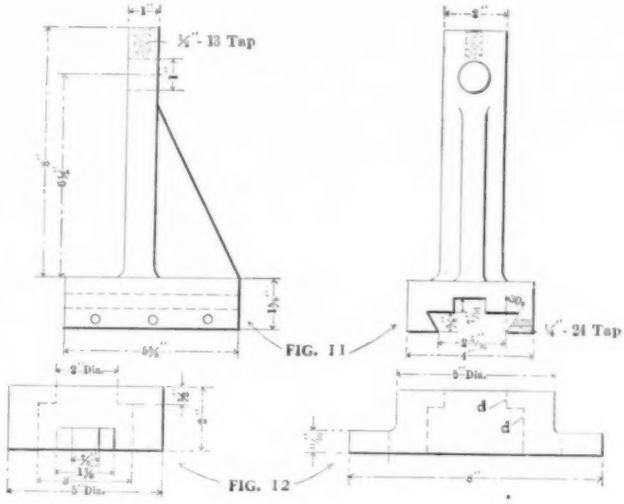
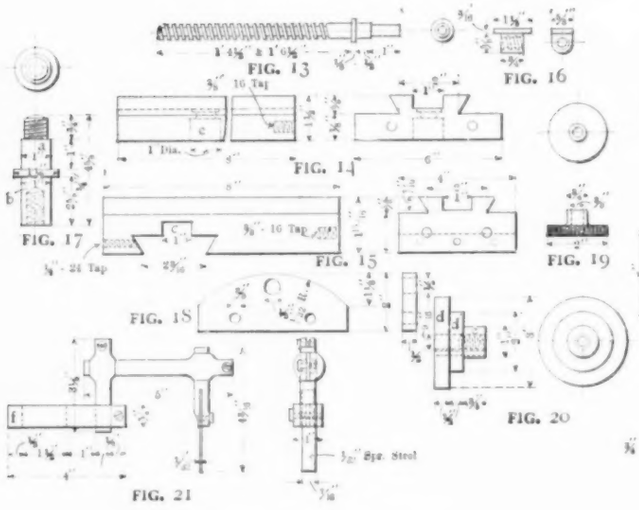


FIG. 10

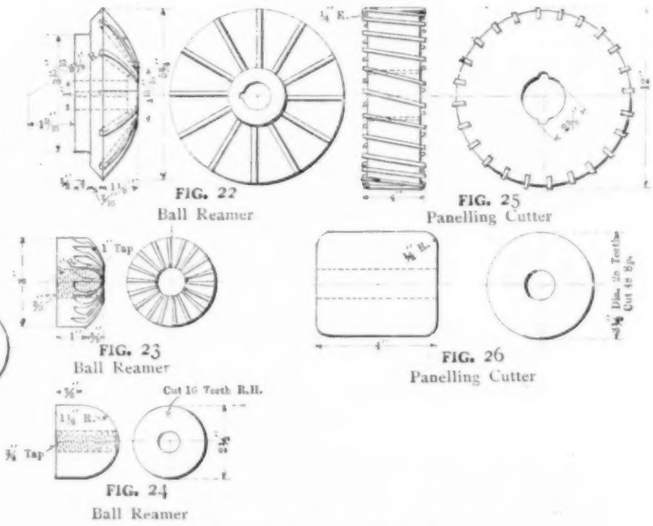
RADIUS GRINDING FIXTURES



THE UPRIGHT OF THE GRINDER



DETAILS OF RADIUS GRINDER



REAMERS AND CUTTERS TO BE GROUND

or pilot invariably being used to steady it, thus insuring a good job.

It is also used very extensively in the boiler shop for cutting flue holes in the tube sheets, dry-pipe holes, etc. A small hole, usually 1 inch in diameter, is punched first for the pilot of the cat head to enter and put on a drill press, and the hole cut to any size desired by having the blades of the proper size.

The accompanying sketches show two of each kind. Fig. 29 is a very handy style for use on the boring mill. It is its large range owing to the easy adjustment of the cutters *C C* and the readiness with which new cutters are made, as they are simply two pieces of tool steel, preferably self hardening, broken off a bar and ground up by hand.

In Fig. 27 is shown an older style, but this is very useful on the drill press on small work, such as oil cups on connecting-rods, etc.; up to a short time ago I believe it was used for cutting out the holes for the rod brasses.

Fig. 27 is one that was made in one

Fig. 30 is the tube hole cutter previously alluded to, for use in the boiler shop exclusively. It consists of a body *F* and shank *G* of tool steel made in one piece. The two slots marked *b b* are then milled and the whole thing is tempered, the retaining ring *H* being tempered also.

The pilot *I* is inserted with a taper fit and pinned by dowel *J*, as shown, owing to their getting broken while in use. The hole *K* is simply a knock-out. The pilot is usually turned about a 1/32 inch small and hardened. The cutters *L L* are

turned and then given clearance. Owing to there being no means of adjustment on this tool, it is necessary to have sets of cutters for each size required, and a good tool foreman will always see that he has some of these on hand ready for all emergencies. This is not very hard to do because the sizes required are not many.

Fig. 29 shows a style of cat head that, although not used so much as those previously named, is nevertheless very useful when required. It is for cutting out large holes in thin stock such as boiler plate. The body *M* is cast iron, finished, as shown, with a 1-inch hole tapped through the central hub for the shank *N* and the pilot *L* to screw into. These are made interchangeable partly for convenience in the making and principally so that the tool can be used on any drill press by changing the shank to suit and so any size pilot may be used. The shank screws up tight against the shoulder and the pilot up against the end of the shank, as shown.

There are two (sometimes four and six) slots *N N* milled in the body for cutters *P P*, which are held firmly in place by cap screws *m m m m*. The cutters shown are offset in order to get a larger hole than could be bored with straight cutters. Straight cutters are used, however, when required, the various sizes being obtained by different depth of slots and shimming, as with the style shown in Fig. 27.

Official statistics have been issued at Rio de Janeiro giving the foreign trade of Brazil for the first six months of 1907. The importation of goods from the United States amounted to $11,673,405, an increase of 24.4 per cent. over the first half of 1906.

A Furnace for High-speed Steel

By James Steel

I presume there are but few shops that have less trouble with high-speed steel than the one where I am employed. We have in the last four years used 14 tons of high-speed steel for tools of all kinds, so the reader can see that we are in the tool business to some extent. Knowing the general results obtained by using high-speed steel, I would not be surprised to see carbon steel entirely discarded in a short time; yet I do not think that high-speed steel will have full sway. The alloyed steels will find their places, and in many instances they will be found of greater value than any other steel in use; for they will be used to help out of the hard places, and to cut steel and chilled rolls that cannot be cut with carbon or high-speed steel, as well as many other places where the cutting edge must be such as will produce a finish on hard work.

There are a few makes of high-speed steel which give some trouble, on account of the steel not being of a composition such as will stand a severe shock or strain. In order that steel may be used in all kinds of tools, it must be flexible, to some extent at least. This not only aids in the straightening of the work after hardening, but the tool will not be so liable to break in use, which is an important factor. Then again we would naturally think that steel of this kind would make a better finishing tool than the steel that will not withstand such a shock. While the strength and grain of any high-speed steel depends entirely on the hardening heat given the steel, yet in order to get the required speed from high-speed steel, it must have sufficient heat in the hardening so that it will not lose its temper in use. I find some high-speed steels when brought to that heat to be very rigid, requiring great care in the straightening after hardening. On the other hand, some of it is as easily bent as a piece of case-hardened work, and with practically no loss in straightening or in use.

In order to heat high-speed steel properly, gas should be used for fuel. There are several good makes of furnaces on the market, especially for high-speed steel, yet a furnace can be built in any ordinary machine shop at a small cost. In building such a furnace the heating chamber is the first thing to consider. The floor or bottom of the heating chamber should be 2 inches wider than the largest piece to be hardened and 4 inches longer than the longest piece. The hight of the chamber should be such that any work to be done can be turned over without danger of striking the work against the top of the furnace. The gas should enter at the sides and 2½ inches below the top of the floor, leaving a chamber on each side ½ inch wide and 2½ inches deep, for combustion, which will also break the force of the air. The door should be smaller than the chamber; in fact, it should be only a little larger than the largest piece of work to be hardened; where there are not very many large pieces to be hardened, it will be well to reduce the size of the door, which can easily be made larger when desired, thus saving gas.

There are several things to guard

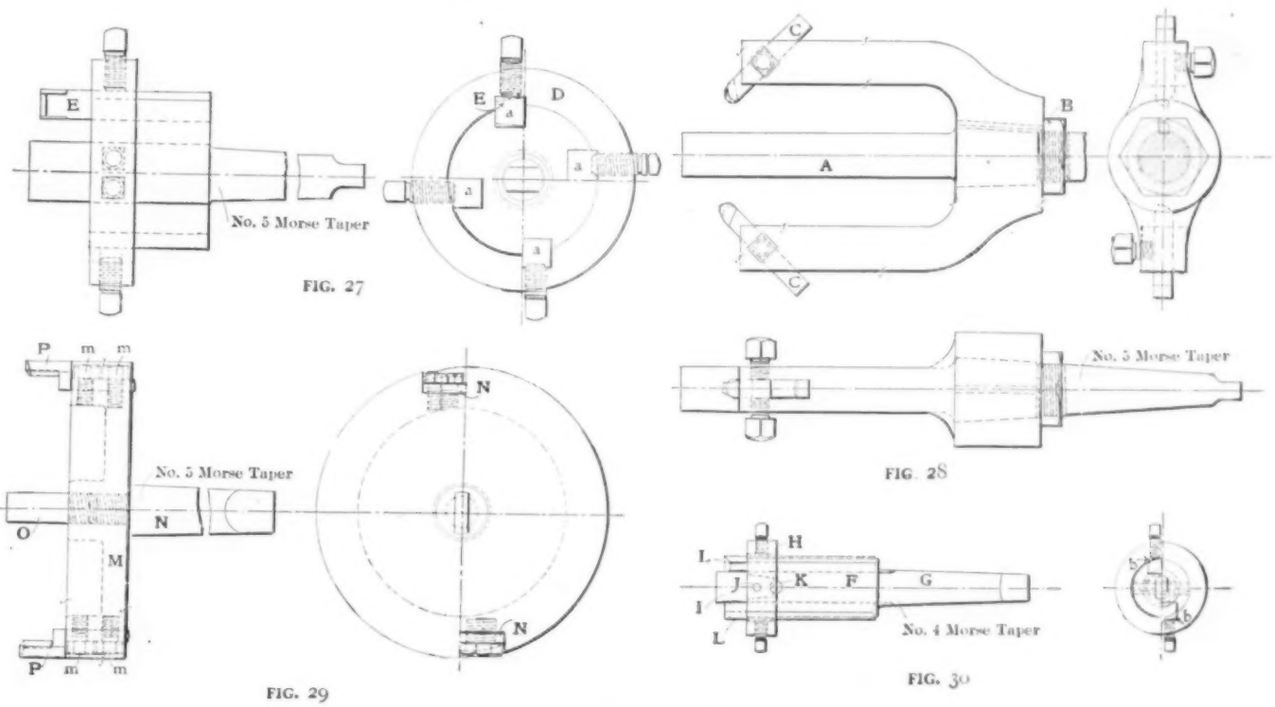


FIG. 27 FIG. 28 FIG. 29 FIG. 30

DRILL-PRESS TOOLS

against in the construction of a furnace for high-speed steel. First, it must be built so that the bottom can be removed without injury to the furnaces, as the bottom will not stand more than ten days' constant use. In making the pattern it will only be necessary to make one piece that will cost very much, that is, the sides; by changing the bosses so that the burners will come opposite each other, both sides can be made from one pattern. One pattern will answer for the four legs, the bottom and end being made plain, as the bottom can be held in place by the groove in the side castings, and the end by cap screws. This will make a neat and durable furnace. The combustion chambers at *a a* should be ½ inch wide, 2½ inches deep and extend the full length of the heating chamber. The bottom or floor of the heating chamber should be built as is shown at *B*, Fig. 1, so that it can be removed without disturbing any other part of the furnace except where the mouth is reduced. The side walls should be built with a wedge brick, as is shown in Fig. 1, at *c c*, thus allowing the side wall to be removed without injuring the other part of the wall or arch. The dotted lines *D* show about how the furnace mouth should be closed for use.

Fig. 2 is a side view of the furnace; the heating chamber is shown in dotted lines. At the point *E* in Fig. 2 is shown the 1-inch gas supply. The air is shown at *F*, ¾-inch supply (being reduced to ⅜ inch just inside of the mixer at the point *G*) and extending 5 inches inside and beyond the point *E* where the gas enters the mixer. The idea in carrying the air in ¾-inch pipes is, first, to insure steady flow; second, to have sufficient volume to connect a pipe in front and just below the mouth of the furnace at the point *I*, thus forcing the heat up and away from the operator. This pipe should have 1/32-inch holes drilled ½ inch apart where it passes under the mouth of the furnace.

Care should be used in bricking up this furnace; the fire clay should not be too heavy. Be sure to fill all joints well and build it so it can be repaired. The furnace can be heated to 1450 degrees Centigrade. It will be seen with this heat that it will be necessary to build with the idea of repairing more or less. The side walls will stand about four months' steady use, but the end wall and arch of the heating chamber seldom give way.

Much could be said in reference to the hardening heat, and as to how to get it. I would much prefer taking a bar of steel, say 5/16 square, and experiment with this until I found the heat that gave the steel the best grain, than to take a finished tool and go at it blindly without knowing just what effect a certain heat will have. Of course high-speed steel is expensive steel to experiment with; but if the proper heat is found with the steel experimented with, its value can hardly be estimated on a day's work.

There are a few points that should be well guarded in the hardening. If the work is large or long, turn often, being sure not to strike it against the sides or bottom. Do not take the work from the furnace until it has had the desired heat through the entire piece, with, of course, exceptions where the cutting edge is very thin and the shank large. Do not be afraid of filling the furnace with work to the extent of covering all the floor of the heating chamber except 1 inch on each side next to the combustion chamber. Do not put the work in until the furnace has

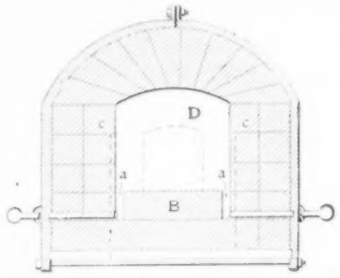


FIG. 1. SECTIONAL VIEW OF FURNACE

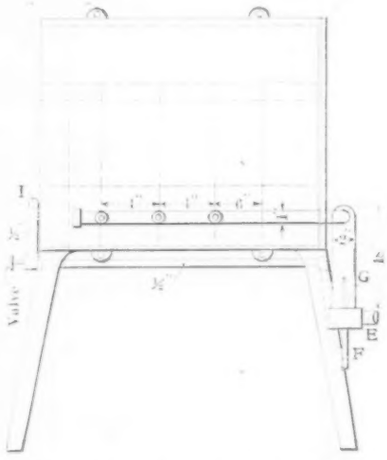


FIG. 2. SIDE VIEW OF FURNACE

reached the desired heat. Regulate the air and gas (being sure not to use too much air) so that the furnace will continue at the proper heat when running empty. Then do not try to harden long reamers and taps in a horizontal furnace. Build one upright on the same principle as the one shown in Figs. 1 and 2. Do not allow the steel to stand after it has reached the proper heat. Do not try to cool a finished tool in air. Use fish oil and do not handle work without tongues that will fit it. Last, but not least, do not try to see the heat with the naked eye; use smoked glasses. This is the only way that a hardener can see when his work has reached a uniform heat.

The production of petroleum in the United States in 1906, according to the Geological Survey, aggregated 126,493,936 barrels, valued at $92,444,735.

The Collection End of the Machine Business

By Ira Chase Koehne

In my 15 years' experience as a mechanical-legal-sales engineer it seems the rule rather than the exception that vast investments in factories, equipment, special tools, etc., for economical manufacture are jeopardized by lack of skill and design in the selling and collection end of the business; and dangerous "leaks" in profits result. Of what account are costly factory, equipment and tools if the sales and collection systems are such that little or no profit results?

Many manufacturers sell their goods by contracts inexpertly drawn and not standardized. Each State has its own laws or court decisions, or both, affecting outright sales, conditional sales, and chattel mortgages. Attempted compliance with such a multiplicity of requirements leads to confusion and mistake, tending to delayed settlements and litigation, to which the debtors are incited by fee-hunting attorneys taking advantage of such conditions, the technicalities of the sales laws, the liability to prejudice in local courts and long delays in consequent appeals.

Even in those States whose laws provide that the filing of sale contracts operates as chattel mortgages upon the property sold, the seller may be and frequently is defeated even when he has complied with such law. This is done by the comparatively execution-proof debtor transferring the property after judgment and before execution, by the usual wording of the contracts the judgment extinguishing the seller's title.

By ordinary means the potency of the Federal courts cannot be invoked unless the sum involved be $2000 and the parties be citizens of different States. I avoid these difficulties, when the article sold is patented, by wording one clause of the sale contract about as follows:

"It is hereby agreed that X. Y. & Co. does not hereby or in any manner release its title to the herein named property, or in any manner release any part of its patent monopoly respecting the same, until after all indebtedness of the undersigned shall have been fully paid in cash to X. Y. & Co., at Dayton, O., regardless of the consideration or form in which said indebtedness may be evidenced or merged."

The debtor signing such contract and who has commenced using the patented machine must pay for it as and at the times agreed, or at the will of the seller; otherwise such debtor may be treated as a patent infringer and proceeded against for injunction and damages in the Federal courts, and the only relief is payment of the debt and the costs. Those taking the property from such debtor are liable to the same treatment. These rights are founded upon Federal laws and are not dependent

upon any State laws. In all exigencies I have found that this means works wonders in fulfilling the proverb that "quick settlements make long friends."

The seller might also comply with any special laws of the debtor's State, so that if litigation were necessary he might bring the ordinary proceedings to get settlement, or the patent infringement damage and injunction suit; or in aggravated cases he might bring both such suits. It also affords opportunity to have patents judicially sustained, to make easier and quicker disposition of any future infringing maker.

The giving, to this important part of the business, of brain power and experience proportionate to that devoted to the making branch would produce quicker results and more profits.

Measurement of Round-head Wood Screws

Replying to an inquiry as to whether wood screws are measured "over all" instead of "under the head," the American Screw Company inform us that the practice is not uniform among all makers; but that they, the oldest makers in the country, have always included in the measurement of round-head wood screws approximately one-half the head.

There may be some difference of opinion as to how this practice originated, but it probably arose in the following way: When they began the manufacture of wood screws in this country in 1838, only flat-head wood screws were at first produced, and in measuring the length of these screws the sheet-metal gage had cut in its edge a nick or recess for receiving the head of the screw, so that the barrel might lie parallel with the edge of the gage. This included the whole of the head within the measured length. When the manufacture of round heads was begun, they were evidently measured in the same gage, allowing the head to fall into this same nick, so far as it would, this of course excluding from the measurement of the length so much of the head as projected back of the nick.

Power Requirements of Railroad Shop Tools*

By L. R. Pomeroy

Generally speaking, the generator capacity for railroad repair shops is equal to approximately 15 kilowatts per locomotive pit, or space in erecting shops occupied by one locomotive. This includes the requirements for tools, cranes, heating, blower and exhaust fans, that is, provides for all power required except that needed for lighting.

The tools alone require about 9 or 10 kilowatts per pit; the heating, and the blower and exhaust fans demand 5 kilowatts per pit, while 3 kilowatts per pit will care for the ordinary shop and adjacent yard lighting. If in addition to shop requirements power is needed for lighting terminal yards, buildings, etc., an increase in generator capacity must be made to cover such demands.

The following curves, Figs. 1 to 8, together with Tables 5 to 10, are submitted to cover the horse-power requirements of the machine tools generally found in railroad repair shops.

Occasionally certain tools are selected for the purpose of performing extra-heavy service, to utilize the full capacity of the new rapid-cutting tool steel, as is now done in manufacturing shops. In such cases the power to drive the machine must be figured on the basis of service required; but as these cases are few and exceptional, the curves will be found to meet the majority of conditions, and the exceptions can be taken care of by the following formula:

$$\textit{Horse-power to drive} = F \times D \times f.p.m. \times 12 \times N \times C \qquad (1)$$

Where:

F = feed in inches,
D = depth of cut in inches,
$f.p.m.$ = feet per minute,
N = number of tools cutting,
C = a constant with the following values, depending on the class of material:

Cast iron	0.35 to 0.5
Soft steel or wrought iron	0.45 to 0.7
Locomotive driving-wheel tires	0.70 to 1.00
Very hard steel, such as crucible-steel driving-wheel tires	1.00 to 1.10

This formula is based on Professor Flather's dynamometer tests, which check up fairly well with actual motor tests, and it is therefore submitted with confidence.

As an example of the accuracy of this formula, the aggregate horse-power of 45 tests made with various tools was 247.7, while the calculated horse-power by formula equaled 247.2.

The extensive tests made by Dr. Nicolson, of the Manchester Technical School, England, confirm the correctness of the foregoing formula and form a very interesting contribution to the subject. A careful analysis of the results of these experiments shows the average horse-power required at the motor, per pound of metal removed per minute, to be as follows:

	Horse-power
Medium or soft steel or wrought iron	2.4
Hard steel	2.65
Cast iron, soft or medium	1.00
Cast iron, hard	1.36

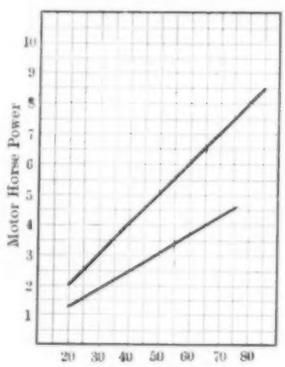


Fig. 1. Drill Press.
15 to 20 Ft. per Min.

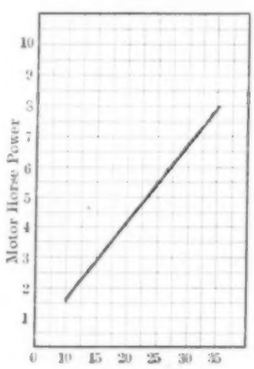


Fig. 2. Shaper.
15 to 20 Ft. per Min.

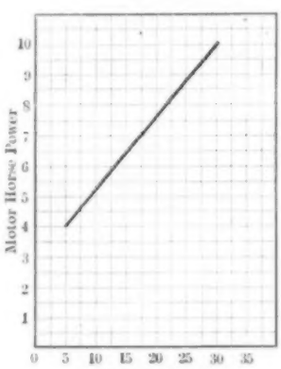


Fig. 3. Slotter.
15 to 20 Ft. per Min.

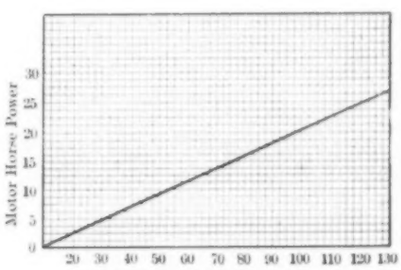


Fig. 4. Boring Mill.
One Tool Cutting 20 Ft. per Min.

HORSE-POWER VALUES FOR MACHINE TOOLS IN RAILROAD SHOPS

Using the symbols of the previous formula, the horse-power becomes:

$$F \times D \times f.p.m. \times 12 \times N \times W \times K \qquad (2)$$

where W equals the weight in pounds of a cubic inch of the metal and K is the coefficient for that metal as given in the table above. The value of W for the different metals is as follows:

Cast iron	0.258
Wrought iron	0.278
Steel	0.284

The following examples illustrate the more or less heavy cuts to which reference has been made; the larger powers given are exceptional, while the average requirements are far below these, and all are submitted as actual cases which have come under the writer's observation:

(a) 100-inch driving-wheel lathe—(material steel driving-wheel tires) 5/16-inch feed, 5/16-inch cut, at 18.5 feet per minute—two tools cutting.

Substituting in formula (1) we have: $5/16 \times 5/16 \times 18.5 \times 12 \times 2 \times C = 40$

*From the *General Electric Review.*

horse-power; same lathe, 3/16-inch feed, ¼-inch cut, at 16 *f.p.m.*—two tools cutting—3/16 × ¼ × 16 × 12 × 2 × *C* = 16 horse-power.

(b) Old 76-inch driving-wheel lathe (material driving-wheel tires), 1/16 × ¼ × 16 × 12 × 2 × *C* = 5 horse-power.

(c) Steel-tired wheel lathe (material engine truck wheels), 1/7 × 5/16 × 16 × 12 × 2 × *C* = 17 horse-power.

(d) Planer (material cast iron), 5/32 inch × ⅜ inch × 16 feet × 12 × 0.35 (one tool cutting), 4.5 horse-power; (two tools cutting) 9 horse-power.

(e) Planer (material wrought-iron engine frame), 5/32 inch × ½ inch × 16 feet × 12 × 2 × 0.5 (two tools cutting), 15 horse-power.

(f) 76-inch boring mill (on cast-steel driving-wheel centers), ⅛ inch × ¾ inch × 30 feet × 12 × 3 × 0.45 (three tools cutting), 45 horse-power. Same machine boring driving-wheel tire, ⅛ inch × 3/16 inch × 28 feet × 12 × 2 × 1 (two tools cutting), 15 horse-power.

(g) 84-inch boring mill (on 62-inch cast-iron wheel centers), ⅛ inch × 1/10 inch × 30 feet × 12 × 3 × 0.35 (three tools cutting), 4.7 horse-power. Same mill boring 44-inch steel tire, ¼ inch × 3/32 inch × 26 feet × 12 × 2 × 1 (two tools cutting), 14.5 horse-power.

(h) The following is a special test on an extra-heavy driving-wheel lathe, and gives results representing unusual conditions. The operator was given a heavy bonus to develop the ultimate capacity of the machine: Average feed, 0.4625 inch; depth, 0.0423 inch, at 12.2 f.p.m. (two tools cutting).

These figures are the averages of 37 tests, and represent a consumption of 40 horse-power, while the maximum horse-power required was about 65. The machine was equipped with a 40-horse-power direct-current motor with 2.1 per cent. speed variation.

The lathe in question was a "special," extra heavy, and of about double the capacity and cost of the standard driving-wheel lathe of equivalent size. On average work, the same investment if expended on two lathes will turn out more work in a year than this special machine.

For rapid estimates the horse-power required can be obtained by the following formulas:

(Single belt) horse-power =

$$\frac{d \times f \times r.p.m}{12 \times 400}. \quad (3)$$

(Double belt) horse-power =

$$\frac{d \times f \times r.p.m.}{12 \times 400 \times 0.7}. \quad (4)$$

where:

d = diameter of smaller pulley in inches,

f = face of pulley in inches,

r.p.m. = revolutions per minute.

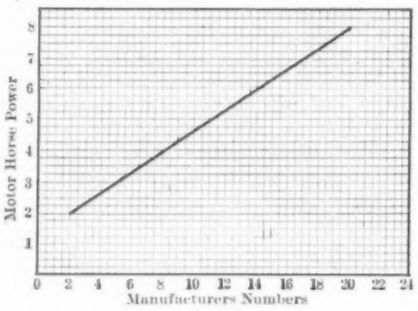


FIG. 3. HORSE-POWER VALUES FOR PIPE-THREADING AND CUTTING MACHINES IN RAILROAD SHOPS

These formulas are very conservative and provide for about as much overload capacity for belts as is ordinarily assumed for motors; they also provide a liberal allowance for the influence of centrifugal force, and for the diminishing arc of contact on the pulley when it is driven from a larger one.

They are especially useful in figuring the power required for wood-working machines and were arrived at largely from experience with such apparatus.

Another formula, adapted from Ruleaux, giving somewhat higher values, is preferred by some, as it considers the thickness of the belt. In this case the allowance for centrifugal force and for the arc of contact, being less than 180 degrees, is taken care of in the selection of values for the constant *C*.

Horse-power = $t \times w \times f.p.m. \times C$ (5), or if the *r.p.m.* and not the *f.p.m.* is known

Horse-power = $t \times w \times d = r.p.m. = C$,

where

t = thickness of belt in inches,

w = width of belt in inches,

d = diameter of pulley in inches,

C = a constant, of following values:

Leather belt	0.0062 to 0.009
Cotton belt	0.0036 to 0.0068
Rubber belt	0.0050 to 0.0082

The tool builders do not always discriminate between the requirements of manufacturing plants and those of railroad repair shops, and for this reason motors are often recommended that are larger than necessary. For example: The *finished* product of the axle departments of such concerns as the United States Steel, Midvale, Bethlehem, and Cambria companies, becomes the *raw* material for railroad shops. In the former shops the forging is turned out from the hammer without much regard to finished dimensions, as it is much cheaper to rough out to size on special rapid-reduction lathes than to attempt to reduce the size under the hammer.

For such machining high power is required; but for the same lathes in railroad shops, where the work performed is mainly finishing cuts on journals and wheel seats, a smaller and cheaper motor may be selected.

The Bement-Miles lathe which was furnished the Howard Axle Works may be given as an example of extreme requirements, such as mentioned. The capacity of this machine is two cuts, each ⅝ × ⅛ inch at 60 feet per minute, and at this rate of cutting the machine will require a 60-horse-power motor.

Another machine, built for the same class of work and used largely in axle shops and in many railroad shops, is capable of taking two cuts of ¾x1/12 inch, at 24 feet per minute. This requires 18 horse-power, and the machine is usually furnished with a 20-horse-power motor.

While this power is all right for the full capacity of the machine, 10 horse-power will cover the requirements of the same tool on average railroad-shop work.

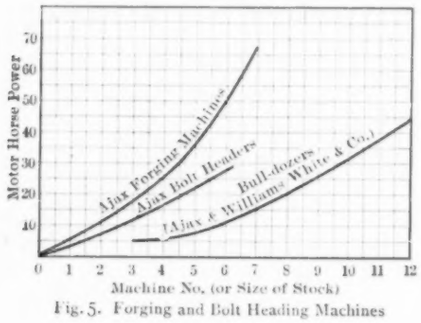


Fig. 5. Forging and Bolt Heading Machines

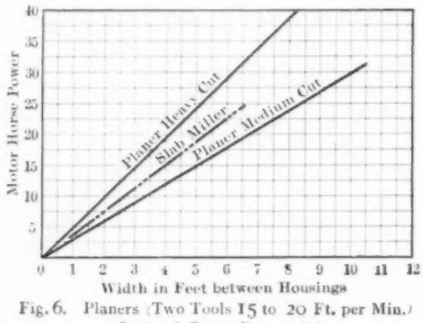


Fig. 6. Planers (Two Tools 15 to 20 Ft. per Min.) Ratio of Cut to Return 1:3

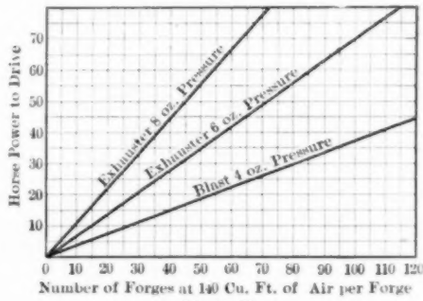

Horse Power to Drive
Exhauster 8 oz. Pressure
Exhauster 6 oz. Pressure
Blast 4 oz. Pressure
Number of Forges at 140 Cu. Ft. of Air per Forge

Fig. 7. Fans

HORSE-POWER VALUES FOR MACHINES IN RAILROAD SHOPS

Engine Pits

Number of pits required =

$$\frac{\text{(Total number of engines)} \times \text{(average number of days in shop)}}{300 \text{ [number of working days in year]}}$$

Examples:

400 engines: average days in shop, 25.

$$\text{Number of pits} = \frac{400 \times 25}{300} = 33.$$

$$\text{Capacity per year} = \frac{(\text{Number of pits}) \times 300}{\text{Average number of days in shop}}$$

In order to reduce to about 20 the average number of days in shop that are required for general overhauling, it is estimated that the machine shop adjacent to the erecting shop should contain seven machine tools per engine pit, and the floor area in order to accommodate seven tools per engine capacity, should be about 1500 square feet per pit.

Power required for air compressors equals the delivery of free air in cubic feet per minute, at 100 pounds pressure of the compressor multiplied by 0.14.

Modern erecting and machine shops, including heating, cranes, etc., cost from $2.50 to $3.50 per square foot of inside measurement.

Rate per kw. hour to cover fixed charges = $\frac{\textit{total fixed charges per year}}{(\textit{max. demand}) \times 8760 \times (\textit{load factor})}$.

Illustration:

Fixed charges.....$8330.00.
Maximum demand.....500 kilowatts.
Load factor.....33 per cent.

Then:

$$\textit{Rate} = \frac{\$8330}{500 \times 8760 \times 0.33} = 0.0057.$$

POWER VALUES FOR VARIOUS MACHINES

BOLT AND NUT MACHINERY, HELVE HAMMERS, MULTIPLE DRILLS, ETC.

	Motor Horse-power Required to Drive.
One and one half-inch single-head bolt cutter	1½
Pratt & Whitney No. 4 turret bolt cutter	2
Two-spindle stay bolt cutter	2
One and one half-inch Acme double-head bolt cutter	2½
One and one half to two and one half Acme nut facer	2½
Six-spindle nut tapper	3
One and one half-inch triple-head bolt cutter	3
Three fourths to two and a half-inch double head bolt cutter	3
Two-inch triple-head bolt cutter	5
Four-spindle stay bolt cutter	5
Bradley hammer	7½
Niles four-spindle multiple-drill	7½

GRINDERS.

	Motor Horse-power Required to Drive
Air-cock grinder	1
No. 3 Brown & Sharpe universal grinder	3
Link grinder	3
Sellers universal grinder for tools	5
Norton 18x96-inch piston-rod grinder	5

MILLERS.

	Motor Horse-power Required to Drive
Vertical miller Becker-Brainard No. 2	1
Valve miller No. 2	2
Universal miller No. 3 Brown & Sharpe	2
Universal miller No. 4 Brown & Sharpe	3
Universal No. 6 Becker-Brainard	5
Niles heavy vertical	10

PUNCHES AND SHEARS.

	Motor Horse-power Required to Drive.
No. 4 36-inch throat L. & A. punch	3
No. 9 horizontal flange punch	5
No. 2 Hillis & Jones combination punch and shear	5
Alligator shear (stock 5x1 inch)	5
Lenox rotary bevel shear	7½
Thirty six-inch multiple tank plate punch with spacing table	7½
No. 3 Hillis & Jones combination punch and shear, 12-inch throat	7½
No. 2 horizontal punch 20-inch throat	7½
No. 3 Hillis & Jones combination punch and shear, 36-inch throat	10
No. 3 angle shear 5x1-inch bar	10

SAWS.

	Motor Horse-power Required to Drive.
Band saw, 36-inch wheel	3
Band saw, 42-inch wheel	5
Swing cut-off saw	5
Band saw, 48-inch wheel	7½
Greenlee No. 1½ self-feed rip saw	10
Greenlee vertical automatic cut-off saw	15
Forty to forty six-inch saws	15
Automatic band resaw	20
Greenlee No. 6 automatic cut-off saw	20
Greenlee No. 3 rip saw	20
Woods No. 4 rip saw	20
Extra heavy automatic rip saw	25

WOOD-WORKING TOOLS.

	Motor Horse-power Required to Drive.
Fay-Egan single-spindle vertical boring machine	3
Fay-Egan three-spindle vertical boring machine	4
Fay-Egan No. 6 vertical mortiser and borer	6
Fay-Egan No. 7 tenoner or gainer	7½
Fay-Egan universal wood worker	7½
Fay-Egan four-spindle vertical borer	7½
Fay-Egan five-spindle vertical borer	10
Fourteen-inch inside molder	12
Fay-Egan universal tenoner and gainer	12
Fay-Egan vertical tenoner	12
Greenlee automatic vertical tenoner	15
Fay-Egan No. 3 gainer, also Greenlee	15½
Greenlee extra-range five-spindle borer and mortiser	15
Greenlee vertical mortiser	15
Fay-Egan automatic gainer, also combination gainer and mortiser	20
Fay-Egan No. 8 vertical saw and gainer	20½
Vertical hollow chisel mortiser and borer	20
Fay-Egan 14½-inch double-cylinder surfacer	20½
Heavy outside molder	20
Six-roll direct-connected planer and matcher	25
Double-cylinder fast flooring machine	30
Double-cylinder planer and matcher	30
Fay-Egan No. 8 automatic tenoner	30½
Woods No. 27 matcher	35
Four-side timber planer, heavy	60

American Trade in South Africa

As already announced in our columns, a Commercial Information Bureau has been established at Cape Town, South Africa, by the American consul-general.

The value of South African imports runs to about one hundred and fifty million dollars annually, and the American trade enjoys but a very small share of this today.

In order to stimulate and increase our business in that portion of the world the Commercial Information Bureau referred to has been established, but it can be of no great service unless those American manufacturers anxious for such business are willing to coöperate with our consul-general in making the bureau a real success. To this end, manufacturers of all classes of machinery, machine tools, and kindred products, are urged to send catalogs, price lists and other information, so that the bureau may be in a position to handle inquiries from prospective importers, in an intelligent and business-like manner.

When it becomes known to possible buyers that the American bureau is in a position to handle inquiries intelligently and expeditiously; when they come to learn that catalogs and supplementary information are on file and accessible, they will naturally consult the bureau when about to make purchases instead of sending the order to the European firm with whom they have been dealing in the past.

Molding with Machinery *

BY JOSEPH H. HART

"Molding machine" is a very misleading name, and it has always seemed to me as if the first fellow that used it was either a rogue, a humorist, or that he didn't know any better; there are still some people using the name of whom the same might be said, though the term has become so common of late that the above applies only to those who use the term to exaggerate statements in a manner to benefit themselves alone.

I like to consider the different so-called molding machines as appliances to facilitate molding, or as so many elements which in a combination of the whole might make a contrivance worthy to be called a molding machine.

Considering the subject in this manner and without prejudice, the three most important and most generally useful (counting all castings in one class) are improved forms of lifting apparatus, mechanical vibrators or pattern-wrapping attachments and squeeze ramming with a yielding platen.

Now it may seem out of place to classify lifts, hoists, cranes, etc., as molding machines, but viewing the output of the foundries in general on a tonnage basis, the improved methods of doing the lifting required in the making of molds is the most valuable application of machinery to molding.

Figuring the problem from the number of molds made, the vibrating or rapping of patterns by mechanical means is the most useful idea yet evolved to facilitate high-speed molding.

As to squeeze ramming, that is the most generally applicable of any form of power ramming; and the use of a yielding platen or water bag in the ramming head of the machine is the most perfect method of application.

PRINCIPLE INVOLVED

Many of the principles involved in the application of mechanical devices to molding are unknown to the majority of those interested in the foundry business at large. This ignorance makes the increase in the use of such devices slower than it really ought to be.

Misleading comparisons of output, overclaims on the part of agents and dealers, ignorance of the machines or the essential points of the problems which they are intended to solve, all have a tendency to hold the movement back. Another cause is that the man who will have the care of the machine and be responsible for its output has little or nothing to say in the selection, equipment or management; under such conditions, of course, he cannot make a very good showing for the machines.

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It is perhaps no one's concern if a foundry owner cares to put good money into a few molding machines with little or no return; but it is nevertheless unfair to the machine and progress in general, for such a man is more apt to speak of the machines as valueless than he is to realize his own ignorance.

The selection of molding machines for any particular foundry should be looked upon as one step in the creation of a system to increase the production of that shop to the utmost by reducing as far as possible the amount of both labor and skill required in the making of its molds. Viewing the problem in this light, it must be recognized as one which, to solve properly, calls for a man with a thorough knowledge of molding and molding machinery, and as a field wherein a "little knowledge" is apt to prove both dangerous and expensive.

Although other reasons do exist, allow for the present that the only one which makes the use of molding machines desirable is an actual saving of labor resulting in a greater return for a given expenditure of energy and see what some elements of molding machinery are worth.

Bench Work

Starting with very light bench work, such as shear blades, key blanks and other gated hardware specialties in either gray or malleable iron, one sees in most foundries making this class of work a large number of men molding on hand squeezers, but on investigating it is often found that only the newer recruits to the art of molding make any use of the ramming head; the more experienced and rapid men are doing the ramming with a pair of rammers, because they can really do it quicker that way than with the squeezer.

Power squeezers are seldom seen on this very light work, for as commonly used even the power squeezer is excelled in speed by hand work; the place where the common squeezer, either hand or power, loses most of its ground is getting the ramming head into position and out of the way again. This very light work requires little ramming; the rate of production by hand being high, in some cases exceeding three hundred molds for nine hours' actual molding by one man, the ramming is accomplished at such a rate of speed that the only way it can be excelled by the use of power ramming is by using a squeeze ramming mechanism which is in constant motion, like a press, to which the molds to be rammed are fed fast enough to keep things moving.

Starting from this point where the increase in output per man by the use of power ramming is zero or less, as the work changes to varieties requiring firmer ramming and deeper mold parts the value of power ramming constantly increases through all the range of work generally molded in snap flasks till its greatest superiority in snap-flask work is found on long narrow snaps, say 10 or 12 inches wide and running up to 48 inches or more in length. Here the actual ramming of the molds may be accomplished about three times as fast by power squeezing as by one specialized molder by hand. This does not mean that the output is three times as great with the machine as without; it is simply the ramming element, and it is one of the high-water marks in actual gain by the application of machinery to molding.

Still considering only the ramming element, take the smaller sizes of work generally made in iron flasks. Starting with flask parts say 14x14x6 inches deep, ramming by power is about one and one-half to two times as fast as by hand; continuing to larger, deeper flasks for split-pattern work, ranging up to flasks 24x24x12 inches or 24x48x12 inches, ramming is from three to four times as fast by the power squeezer as it is by hand and another high-water mark is reached. This is also about the limit of size for flasks without bars in general practice in green-sand molding.

As the use of cross bars becomes necessary in molding machine flasks, the value of power squeezing takes a sudden drop till it is below that of hand ramming and really stays there on all larger and heavier classes of work, although a few extravagant installations might seem to contradict me.

The Vibrator

As I said before, the vibrator is a very valuable element of machine molding. Back in that shop I spoke of as making the very light bench work, and there are hundreds of others, every molder was rapping his pattern through the cope before lifting it off and later drawing the pattern with a wooden plug and tapping iron. By using a vibrator or its equivalent, this rapping is unnecessary; although the time saved per mold may seem a very small matter, amounting on the simplest work to little more than 1 per cent., its value constantly increases, in proportion, as the pattern presents greater difficulties in obtaining a good clean lift or draw. Also with accurate flask-lifting apparatus, the vibrator can be made to prove that a large percentage of the stripping plates in use at present are a needless expense.

The vibrator will be adapted to larger classes of work in due time, but even at present it is the most valuable of all mechanical aids to the molder on small work, and a subject which should be well studied by jobbing foundrymen handling this class of work.

Mechanical Lifting of Molds

Now as to the mechanical methods of lifting and carrying the molds or any of their parts. Conveyers, etc., really come under this head; but as they are only used in extraordinary cases, I will ignore them for the present.

The start in lifting machines as applied to molding is the flask-raising apparatus as applied to certain molding machines and operated by either a hand lever or power. Its actual value it is perhaps impossible to express intelligently; but to state the matter plainly, these lifting mechanisms start the flask parts squarely and evenly from the pattern and keep them going in a straight line as far as the plungers will reach, so that with properly drafted patterns, with the use of a proper rapping mechanism and with lifting plungers long enough, you can go very nearly all the way through machine molding without requiring any stripping plates.

As to cranes and hoists: when the molds or any parts of them are of such a weight that two men cannot handle them easily enough to do so rapidly, in fact to run with them if necessary, it is time to invest in some kind of cranes or hoists for use in connection with molding machinery. Speed is a very important factor, but thorough control of that speed is a greater one.

Air hoists are without doubt the best form of crane for light machine-molding floors, where the number of molds made is large; but some air hoists are hard to control and need better care than is usually at hand in the foundry.

As we get molds which are larger, heavier and require more careful handling, the electric hoist is the most desirable, beginning with the smaller ones which run on a single I-beam up to the largest traveler used in foundry work.

The most important elements in molding machinery are squeeze ramming machines, rapping or vibrating attachments and improved lifting machinery. The lifting machinery is the most generally applicable of any, for it is a direct factor in the more rapid molding of all classes of work from some of the heavier classes of bench work up to the heaviest loam work. Incidentally I might add that cranes are apt to prove very valuable without molding machines; but with few exceptions molding machines without proper crane equipment are a mockery.

The first test of the largest gas engine in the world was made recently by the Carnegie Steel Company at the Edgar Thomson plant. The big machine ran perfectly. Through it the Carnegie Company expects to save immensely in its fuel bills per annum, since the engine uses blast-furnace gas exclusively.

The machine weighs 1,500,000 pounds, is 86 feet long and its horse-power is 5000. It was designed by Carnegie and Westinghouse engineers to take advantage of the secret process discovered by the Carnegie Company some time ago by which the waste gas of the blast furnaces, which has been poisoning the atmosphere of Pittsburg and has been a source of infinite expense to the Steel Corporation, is led back into the engine as fuel.

The Safe Working Loads for Gear Teeth

Resistance to Wear Is of As Much Importance As Resistance to Fracture. Formulas to Properly Design for This Factor

BY CHAS. H. LOGUE*

In Vol. 27, at page 257, of the AMERICAN MACHINIST there appeared an article by Harvey D. Williams, entitled "The Measurement of Contacts." This paper is worthy of more than ordinary consideration as it throws light on a phase of gear transmission which has heretofore been but vaguely realized.

The Lewis formula is the best method of figuring the power of gears so far as the actual strength of the teeth is concerned, but takes no account whatever of wear and the value of the tooth surfaces to resist crushing of the material. Trouble from this source is a common experience, although not properly understood, as it is sometimes difficult to account for the "mysterious" failure of gears that were apparently of ample strength. It is noticed that gears generally fail through wear and not by fracture of the teeth, also that the teeth often break at a load far below that which is considered safe. More attention, therefore, should be given to this point.

According to the article referred to above, a certain combination of diameters will carry but a certain load per unit of face, irrespective of the pitch of the gears, so that there is no gain in an increased pitch above that just sufficient to resist fracture. This pitch may be found as usual by the Lewis formula, but the actual strength of the material should be used. The material in a 1-inch pitch tooth is stronger proportionately than the same material in a 2-inch pitch tooth. This is caused by the fact that nearer the exterior the material is stronger and of a closer grain, due to rapid cooling. A tooth is stronger at the top than at its root. Test pieces from these points have shown a difference in strength of 30 per cent. To obtain accurate results, therefore, test pieces should be cut from the gear at the root of the tooth, as this is the point of fracture. This applies to forged steel as well as to cast steel and iron, as in the forging the material is condensed and refined on the exterior by working. It would seem as if tests of material should be made for flexure and not for tensile strength, as the tooth breaks through bending. The average ultimate strength of cast iron for flexure is 38,000 pounds per square inch, while the tensile strength is 24,000 pounds per square inch.

Aside from this feature the surface hardness should also be considered irrespective of the strength of material. For instance, a pressure of 5000 pounds per unit of contact would be allowed for a case-hardened steel surface, while but 1200 would be allowed for the same material in its unhardened condition. I have assumed most of the values given in this article, and they are approximate only. Their actual values should be obtained from tests for hardness by the Brinell ball test, which consists of forcing a hardened-steel ball into the surface of the material being tested, so as to effect a slight impression, the dimensions of which will serve as a basis for ascertaining the properties of hardness.

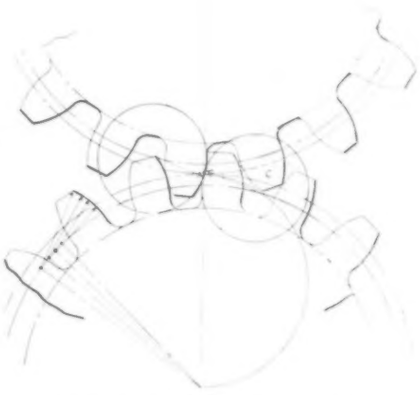

FIG. 1. GEAR TOOTH ACTION

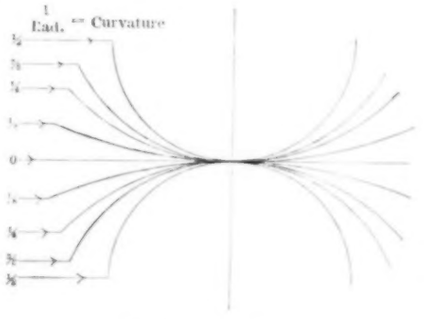

FIG. 2. CURVATURES

The comparative hardness of material thus obtained, in conjunction with the coefficient of friction for different grades and hardness of material engaging, will supply the safe load A per unit of area. See formula (6).

HARDNESS OF MATERIALS AFFECTS WEARING QUALITIES

To illustrate the value of these coefficients: Two engaging gears of machine steel will wear excessively, while such is not the case when one of the same gears engages with one of cast steel or iron. Two cast-steel gears or two cast-iron gears will wear very well together, although when cast steel is employed the pinion should be of the harder material, say by the introduction of a high percentage of manganese. With machine steel of a low carbon, better results are obtained when one of the gears is made of a high percentage of carbon. For instance, two gears each of 0.20 carbon will not wear as well as two made of 0.20 and 0.40 carbon respectively, and excellent results are obtained from such gears, 0.20 carbon or under, when the teeth are case-hardened.

Two soft materials do not wear well together, while two hard materials do. Take, for example, the comparative adhesion of babbitt and babbitt as against case-hardened steel and case-hardened steel; while babbitt will wear well when engaging a steel surface, a hardened-steel shaft will render good service in a hardened-steel bearing.

It is true that the arc of rolling contact in gears is very small; the balance is sliding contact, which increases proportionately over the rolling contact as the pitch points separate, or as the tooth disengages, and decreases as the tooth enters contact until the pitch points again engage where it is rolling.

The wearing qualities of the teeth depend greatly upon their condition when put into service. If a little care is used to obtain a smooth surface at the start and allow the teeth to find their proper bearing, the gears will wear indefinitely longer than if put under full load when new, no matter how accurately the teeth are cut. Also a gear once started to cut can often be saved by the timely application of a fine file, finally smoothing the teeth with an oil stone.

A series of experiments to determine the proper load per unit of contact (A) for different grades and hardness of material used would certainly lead to a fuller knowledge of the capacity of gears for the transmission of power and leave less to supposition on the part of the designer. On account of the peculiar nature of the tooth contact it is quite likely that the best manner to reach accurate results would be with gears made from the materials under consideration.

The idea of limiting the load to the proportion of the gear diameters irrespective of the pitch (for a unit of face) may at first appear startling; but when we consider that the radii from which the tooth is drawn are always proportional to the *pitch diameter* of the gear and not to the *pitch*, and that the teeth in contact are actually two cylinders rolling and slipping

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upon each other, it appears more reasonable. See Fig. 1. It should be understood, however, that the diameter and position of these rollers change constantly throughout the contact, and that a gear made in strict accordance with Fig. 1 would not give a uniform movement. It illustrates, however, the principle of tooth contact.

When the point of contact has moved to the point C, the radii from which the engaging section of teeth are drawn will change in length, as the involute curve changes its radii constantly; the result is that the rollers are not of an even diameter as when engaged in Fig. 1 at the pitch point. To secure safe results the flank or shortest radius is used in these formulas.

The following is the gist of the article referred to with its application to gear transmissions:

"The curvature of a plane curve is defined by mathematicians as the change of direction per unit of length, and is equal to the reciprocal of the radius of curvature at the point considered. Thus in going once around a circle of radius R the distance traversed is the circumference $2\pi R$, while the change of direction is in circular measure or radians 2π.

"The change in direction per unit of length is therefore:

$$\frac{2\pi}{2\pi R} = \frac{1}{R}.$$

"Accordingly the curvature of a 2-inch circle is 1, that of a 1-inch circle is 2, that of a ½-inch circle is 4 and that of a straight line is $\frac{1}{\infty} = 0$, etc. . . .

"The curvature of a straight line being zero, that of an arc may be said to be its curvature in relation to the straight line, or its *relative curvature* to the straight line. Similarly, in comparing the curvature of two arcs, it will be convenient to use the term 'relative curvature' instead of the difference of curvature, meaning thereby the algebraic difference of the curvature as dimensions in Fig. 2.

"It will be seen that when two plane curves are tangent to each other externally the relative curvature is to be found by adding the respective curvatures, and when they are tangent internally the relative curvature is to be found by subtracting. . . .

"The amount of contact between plane curved profiles is measured by the reciprocal of the relative curvature." See formulas (3), (4) and (5).

In each of the cases shown by Figs. 3, 4 and 5 the contact is 4, and if these profiles were made of the same material and the same width of face, they would be equally efficient as regards their ability to withstand pressure.

Development of Formulas

Let

C = the contact.
R^1 = the flank radius of the gear.
r^1 = the flank radius of the pinion.
f = the face width.
V = the velocity in feet per minute.
A = the safe crushing load per unit of contact.
D^1 = the pitch diameter of the gear.
d^1 = the pitch diameter of the pinion.
ϕ = the angle of obliquity.
W^c = the safe load on the tooth to resist crushing and wear.
W = the safe load on the tooth to resist fracture.

Then

$$R^1 = \frac{D}{2} \sin. \phi, \qquad (1)$$

and

$$r^1 = \frac{d^1}{2} \sin. \phi. \qquad (2)$$

For spur gears

$$C = \frac{1}{\frac{1}{r^1} + \frac{1}{R^1}}. \qquad (3)$$

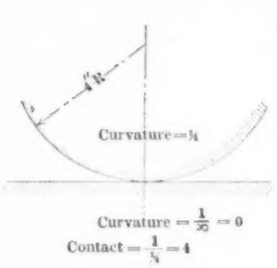


FIG. 3

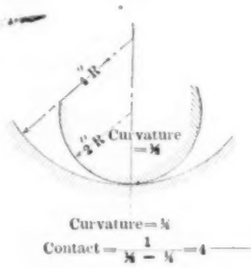


FIG. 4

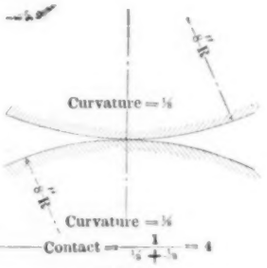


FIG. 5

CONTACTS OF THE SAME RELATIVE CURVATURE

For internal gears

$$C = \frac{1}{\frac{1}{r^1} - \frac{1}{R^1}}. \qquad (4)$$

For racks

$$C = \frac{1}{\frac{1}{r^1} \pm 0} = \frac{r^1}{1} = r^1. \qquad (5)$$

Values of A are:

For rawhide and cast iron, $A = 600$;
For cast iron and cast iron, $A = 900$;
For machinery steel and machinery steel, $A = 1200$;
For machinery steel and cast steel, $A = 2250$;
For cast steel and cast steel, $A = 2250$;
For machinery steel and machinery steel, case-hardened, $A = 5000$.

$$W^c = C f A \left(\frac{600}{600 + V}\right) \qquad (6)$$

Examples Using the Formulas

Required the safe load on the teeth of a pair of spur gears of the following dimensions:

The gear has 75 teeth, 5-inch pitch, 20-inch face, 120-inch pitch diameter and is made from cast steel.

The pinion has 25 teeth, 5-inch pitch, 20-inch face, 40-inch pitch diameter and is made of cast steel.

The speed is 1200 feet per minute, and the angle of obliquity is 14½ degrees.

Then

$$R^1 = \frac{120}{2} \times 0.25 \ (sin. \ of \ 14\tfrac{1}{2} \ degrees)$$

= 15 inches, flank radius of the gear,

and

$$r^1 = \frac{40}{2} \times 0.25$$

= 5 inches, flank radius of the pinion.

$$W^c = \frac{1}{\frac{1}{5} + \frac{1}{15}} \times 20 \times 2250 \times \frac{600}{600 \times 1200} = 3.84 \times 20 \times 2250 \times 0.333$$

= 57,900 pounds.

These same gears, according to the Lewis formula, would carry a load of 64,670 pounds.

In case neither the diameter nor the face of the gears could be increased to carry the load given by the Lewis formula, the angle of obliquity may be increased to obtain the desired result.

In the above case say 19 degrees is tried. Its sine = 0.326.

Then

$$R^1 = \frac{120}{2} \times 0.326 = 19.56 \text{ inches},$$

flank radius of the gear,

and

$$r^1 = \frac{40}{2} \times 0.326 = 6.52 \text{ inches},$$

flank radius of the pinion.

$$W^c = \frac{1}{\frac{1}{6.52} + \frac{1}{19.59}} \times 20 \times 2250 \times 0.333 = 4.9 \times 20 \times 2250 \times 0.333$$

= 73,000 pounds.

If the pinion in the above example engaged a rack, our formulas would give the following:

r = 6.25 inches and

$W^c = 6.52 \times 20 \times 2250 \times 0.333 = 97{,}800$ pounds.

The Lewis formula for this angle of obliquity would allow a load of 66,670

pounds, but 73,500 pounds is the maximum load for gears of this diameter, face and angle, no matter how heavy the pitch is made. Suppose that the pitch of the gears in the above was made 9.7 inches instead of 5 inches, the example would then read: Required the safe load on the teeth of a pair of spur gears of which the gear has 39 teeth 9.7 inches pitch, 20 inches face, 120 inches pitch diameter, and is made of cast steel. The pinion has 13 teeth 9.7 inches pitch, 20 inches face, 40 inches pitch diameter and is also made of cast steel.

$$W = 20{,}000 \times 9.7 \times 20 \times 0.083 \times 0.333 = 110{,}110 \text{ pounds.}$$

It is apparent that this load would rapidly destroy the teeth through wear, although they are amply strong for the load.

If the gear in this example was made an internal 5-inch pitch, the value of W^e would then be found as follows:

$$W^e = \frac{1}{\frac{1}{6.52} - \frac{1}{19.56}} \times 20 \times 2250$$

$$\times 0.333 = 10 \times 20 \times 2250 \times 0.333$$

$$= 150{,}000 \text{ pounds.}$$

This will illustrate the value of this formula as applied to internal gears. Of course it will be seen that to carry this load it would be necessary nearly to double the pitch if the theory that the entire load is borne on one tooth is followed out; but by referring to Fig. 6 it would appear that such is not always necessary, especially when the spur gear is large in proportion to the internal gear.

Relative Importance of Strength and Hardness

It would appear that the actual *strength* of the tooth is to be a secondary consideration, figured only as a preventive against fracture. The real points to be considered are: First, the proper proportion of the gear diameters; second, the hardness of the material and the best combination of hardness for wear. George B. Grant was very near the truth in saying, "It does not proportionately increase the strength of a tooth to double its pitch." With herring-bone gears it would seem that the strength need hardly be considered, as it is practically impossible to break out a single tooth; an entire section must be removed.

Aside from the hardness, the value of the material to avoid crystallization must be considered, as gears in which the teeth are apparently extremely tough will often become brittle and drop off after a comparatively short service from this cause. For this reason high-carbon steel should be avoided and hardness obtained by case-hardening, or by the addition of manganese, nickel, chromium, or some other hardening ingredient.

It is hardly necessary to add that proper lubrication adds greatly to the efficiency of a gear drive, except, of course, where they are exposed to brick or cement dust, where it is often advisable to run them dry, as the oil will hold particles of grit and cause the teeth to cut. A jet of air applied at the point of contact is also found beneficial in such cases, as it will remove particles of grit from the teeth before they enter contact.

The constructions of housings upon which the gears are mounted is of the utmost importance, as the absence of vibration is essential to high efficiency. Where the housings are insecure it is often found that a rawhide pinion will give better service than one made of steel, as the rawhide will give and absorb vibration that would destroy the harder material.

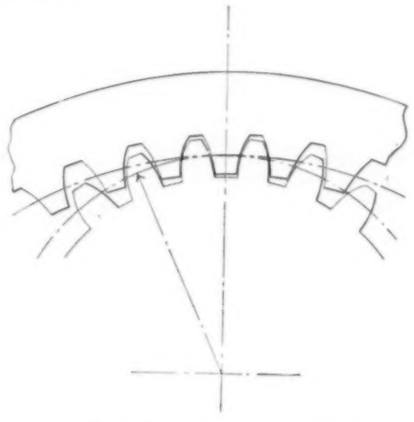


FIG. 6. INTERNAL GEAR MESHING WITH SPUR

FIG. 7. LIMITING WEAR OF GEAR TEETH

Another point that naturally suggests itself is the proper value of a suitable lubricant. It is evident that the efficiency of 95 per cent. running dry and 98 per cent. when immersed in oil does represent the total saving. Lubrication means in many cases the difference between a successful drive and a failure which is not apparent from any superficial tests made for power efficiency only.

The question is often asked, "What is the life of a gear?" It is evident that continual service will wear out *any* material no matter how hard. We will say for example that a load of 900 pounds per unit of area will wear out a pair of cast-iron gears in one year's continual service. What pressure must be applied, therefore, to wear out these gears in six months or to allow them to run for five years? It would appear that this could be taken care of nicely by factor A, provided, of course, that other conditions are correct and that we have the proper analysis of our materials. We should determine not only what grades of material will wear best together, but also how long they will wear.

A gear may be said to be worn out when the teeth have been reduced to not less than one-half their original thickness; this will subject them to the limit of ultimate stress of the material if allowed their full load according to the Lewis formula. If this is exceeded the teeth would be liable to fracture. See Fig. 7.

It is evident that during the latter part of the life of a gear that the teeth will wear more rapidly, as the backlash will allow the teeth to hammer with variations in the load or in reversing.

It is well known that all materials are subject to what is known as fatigue; that is, a piece of steel that will stand an intermittent strain of 2000 pounds successfully is liable to fail if this load is permanently applied. This should enter into our problem as it is often required to design a pair of gears to transmit a certain load continuously, with the guarantee that they will render successful service for, say, two years before renewing. The correct solution of this problem would require a thorough knowledge on all the points brought up in this paper; unless, of course, the gears were made amply large, or there had been some precedent upon which to base the calculations.

Another point to be considered is what difference (if any) should be made in the comparative hardness in favor of the pinion, as it is evident that it will have an excess of wear proportional to the ratio of the pair.

Importance of Proper Design

Aside from all these conditions, to obtain anything like accurate results the gears must be mounted in such a manner as to obviate practically all vibration. The teeth must be accurately formed and spaced to insure that the impulse received by the driven gear is uniform and without variation, and the thickness of the teeth must be such as to avoid practically all backlash, except just enough to secure free operation, as teeth are often broken by crowding on close centers. The gears must also be properly designed to withstand any strains to which they are subjected. The proper distribution of the material will add greatly to the wear and strength. It is well to have the gear as rigid as possible. It should be remembered that accuracy in cutting the teeth will be of little avail if they are not correctly mounted upon their shafts. If the shaft is a little under size, the key will cause it to run out of true. This will also apply when the shaft is a neat fit and the key is driven too tightly. To avoid this it might be good practice to put in two keys diametrically opposite each other, or to use a split bolted hub, or by shrinking steel bands on the hub projections. When the gear is necessarily moved a considerable distance on the shaft before reaching its

bearing, the bore is often made eccentric. It is natural that the tighter the gear fits the axle the more rigid it will be, and the higher its efficiency. Gears for high speed should be balanced for obvious reasons.

In the absence of practically all experimental data I have not attempted to put forward anything more than a general outline of the situation and to bring up essential points for consideration. It is trusted that they will be received as such. In view of the growing importance of gears for the transmission of power the points referred to are certainly worthy of attention, and it is believed practical workable data may be evolved.

Not far behind the development of the land turbine has been the successful application of this type of prime mover to the propulsion of ships at sea. For this service one type in particular, the Parsons horizontal turbine, has been used almost entirely. The recent record trips of the large ocean liners calls special attention to the turbine.

Standard Tool Posts

By Frederick Oyen

While the necessity of standardizing the products of machine shops has been generally realized during late years, the standardization of the machine-shop equipment, aiming at uniformity in tools and methods, has been badly neglected.

F. W. Taylor, in his several papers relating to machine-shop management, has forcibly pointed out the value of such standardization and published very valuable data in regard to cutting tools, etc. In addition to this information Wm. H. Taylor has recently published detailed information in regard to forging and grinding such tools.

In order to use the tools advocated by Mr. Taylor it is necessary to standardize the tool posts on all lathes and boring mills in the shop. It would indeed be a great saving to the country if machine-tool builders in the future would lower their tool posts and design them so as to take care of the vertical adjustment made necessary by grinding the tools down from the maximum to the minimum hight of nose.

Fig. 1 shows a tool forged up with a high nose. H is the hight of the tool after the first grinding, h the hight after the last grinding (when the tool is ready for being reforged and dressed). $H - h = A$, which is the necessary vertical adjustment to be provided for. The accompanying table gives all the necessary information for tool posts for tools from ½x¾ inch to 2x3 inches.

Fig. 2 shows as an example a tool post for a 16-inch lathe, designed for a ⅝x1-inch tool.

Each lathe must be furnished with a set of shims varying in thickness from 1/32 inch up, each shim being twice the thickness of the next smaller size, as: 1/32 — 1/16 — ⅛ — ¼ — ½ — 1 inch, etc. In shimming up the tool it may be necessary to use several shims; in order to determine quickly what shims to use, each lathe should be provided with a graduated plate as shown in Fig. 3.

A convenient location for this plate is at the headstock, preferably above a finished surface. The operator puts his tool with the bottom on the finished surface and the nose against the graduations. A glance at the graduations tells him what shims to use. Thus in Fig. 3 where

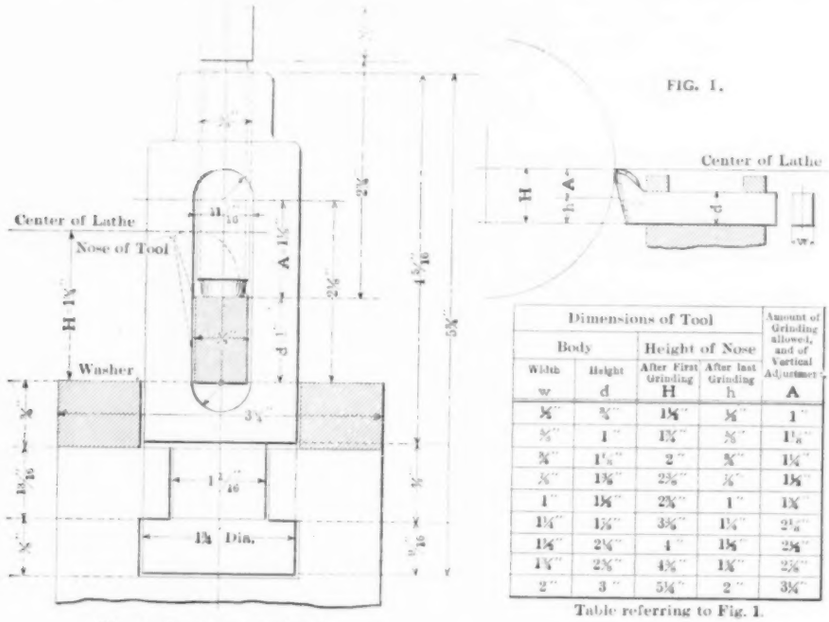


FIG. 2. Tool Post for 16" Lathe Designed for ⅝" x 1" Tool

FIG. 1.

Dimensions of Tool				Amount of Grinding allowed, and of Vertical Adjustment
Body		Height of Nose		
Width w	Height d	After First Grinding H	After last Grinding h	A
½"	⅝"	1⅝"	⅝"	1"
⅝"	1"	1⅞"	⅞"	1 1/8"
¾"	1 1/8"	2"	⅞"	1¼"
⅞"	1⅜"	2⅛"	⅛"	1⅜"
1"	1⅝"	2⅜"	1"	1⅜"
1¼"	1⅞"	3⅛"	1¼"	2⅛"
1⅜"	2¼"	4"	1⅜"	2⅝"
1½"	2⅝"	4⅜"	1⅜"	2⅞"
2"	3"	5¼"	2"	3¼"

Table referring to Fig. 1.

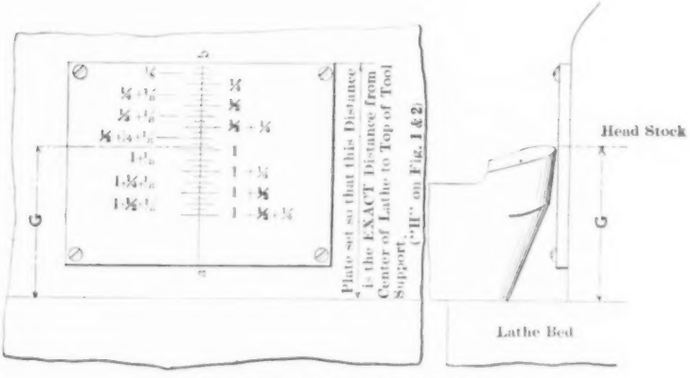


Plate set so that this Distance is the EXACT Distance from Center of Lathe to Top of Tool Support. ("H" on Figs. 1 & 2.)
Head Stock
Lathe Bed
G

FIG. 3. (Showing method for quickly determining what Shims to use for any Tool.)

STANDARD TOOL POSTS AND TABLE

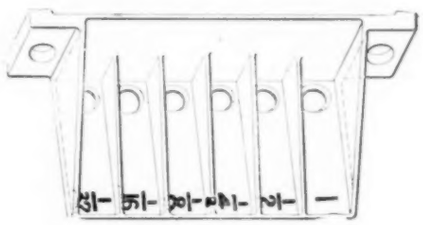


FIG. 4. TRAY FOR SHIMS

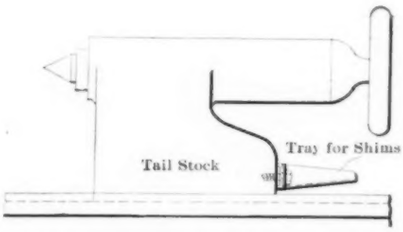


FIG. 5. CONVENIENT PLACE FOR SHIM TRAY

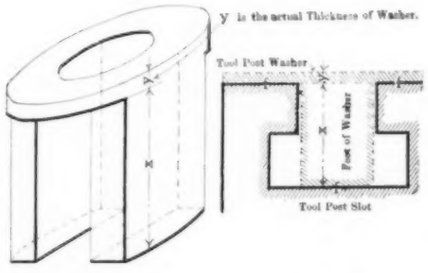


FIG. 6. SPECIAL TOOL-POST WASHER

the hight of the tool is *G*, the following shims are necessary: ½, ¼, ⅛, 1/16 and 1/32 inch.

The shims must of course be accurately finished and can be made of tool steel or machinery steel; in the latter case they must be case-hardened. In order to keep these shims handy at the lathe and also to make it easier for the machine inspector to see that everything is all right, a tray for these shims (Fig. 4) should be fastened in a convenient place such as at the back of the tailstock, as shown in Fig. 5.

These trays can be made very thin iron castings and should have raised figures for each size shim, as shown in Fig. 4.

In order to get a good support in the tool posts, all tools are ground on the bottom.

When changing old tool posts on small lathes it is sometimes necessary to cut down the hight of the tool-post washer to such an extent that it would be entirely too weak to resist the bending moment if made a flat washer.

Fig. 6 shows a special washer to be used in such a case. This washer has two feet which touch the bottom of the tool-post slot, thus in the dangerous position of the tool, it carries the pressure to the bottom of the tool-post slot and preventing any bending moment on the washer.

What Evening-school Shop Work Is Doing

By E. R. Markham

At the present time, when the subject of industrial education is receiving so much attention it seems fitting to say a few words regarding a school where shop men who have not had certain advantages may, by spending three evenings each week for twenty-one weeks, improve themselves and become to a degree familiar with machines and operations that they knew nothing about.

An Era of Specialty

The present is an age of specialization, and comparatively few men have an experience that makes them all-round men. They learn to run certain machines, or a certain machine, or more often they learn to do certain operations on a machine. While such a man may be particularly skilful in his particular work, he has little to look forward to so far as advancement is concerned. He may be of little value in any shop other than the one he is working in.

The establishment of evening shop-work classes was begun several years ago, and the writer was connected with a school of this kind in Springfield, Mass., for several years, beginning in 1900. This school, which was somewhat in the nature of an experiment at first, proved its value and gained rapidly in favor, so that at the present time they are not able to enroll all the applicants.

Evening School Established

Several years ago the school committee of the City of Cambridge, Mass., decided to open the shops in the Rindge manual training school evenings to shop men who were anxious to improve themselves. The instructors in the day school, being practical journeymen in the various subjects they teach, were selected to take charge of the evening courses under the supervision of the principal of the school.

The former principal of the school resigned early in the present year to become secretary of the Massachusetts State Board of Industrial Education, a commission established to devise methods whereby trades may be taught in schools specially fitted and run for that purpose if, in their judgment, such method of training seems advisable.

The State Board of Industrial Education is this year coöperating with the school committee in the maintaining and running of the evening school. Men working in shops are admitted to the shop that will give them instruction along the line they are working upon in the daytime.

It will be seen that a man sufficiently interested to attend a school in the evening after working all day comes there for business.

Choice of Subjects

The man is allowed to choose the particular line of instruction he is to receive, provided his previous training has fitted him for such instruction. If, however, such is not the case, he is shown the necessity of a certain intermediate training in order that he be able to grasp the particular branch he is anxious to get.

Last year we had in the machine shop two men who were skilful workmen (die-makers) who wanted instruction in hardening dies and intricate pieces which generally give trouble when hardened. We had a number of men who worked on engine-lathe work, but who were not familiar with certain classes of work. These men were skilful so far as they had had opportunity to learn, and when given the opportunity under instruction they made rapid progress. Several of them were able to get positions where they received an increase of pay on account of their increased ability. A number of the men, on account of the advance they had made, were able to get more pay in the shop where they were working.

This year we feel that the men will be able to show a marked improvement over the pupils of former years on account of certain innovations which we have every reason to think will be instrumental in helping them.

The pupils of the machine shop are divided into three classes in arithmetic. The first class is made up of men who have never received much instruction in this study. The second class is composed of those who have some idea of the study; this class commenced with the study of common fractions. The third, or advanced class, includes those who are pretty well versed in this study and take up practical shop problems and formulas. They are given these problems and formulas in the form of notes; then in the class the working of the various problems is explained to them, and they are given examples to take home and work out. The men are enthusiastic over this innovation and I am sure it will be the means of a great deal of good, as they are taught to work out the cubical contents of blocks and bars of various forms, and also the weights; the measuring of belting in the coil; the working out of tapers; how much to set over the tailstock of the lathe to produce a given taper; how to find the tap-size hole for a thread when the diameter of the screw and the pitch and form of thread are given; to find the change gears for screw cutting on simple and compound-geared lathes; problems in gearing, belting, speeds, horse-power of engines; and the various problems that are constantly coming up in shops and which so few of the men are able to solve.

Compilation of Notes

The notes that are furnished the men are written out by the instructors, and are then typewritten and mimeographed on a standard-size note-book paper which can be inserted between covers furnished the men. At the end of the year they will have a fairly complete text-book covering the work they have had, for they not only cover the mathematical work, but the various work done in the shop. While this innovation entails considerable extra work, it should prove a valuable thing for the men.

There has been furnished us a machine called a reflectroscope. This may be used as a lantern-slide machine, or a picture from a paper or book may be thrown on a screen, showing a much enlarged view, thus enabling the instructor to illustrate his talks by means of pictures without the trouble or expense of lantern slides. This, we are certain, will prove a valuable addition to our equipment. It is a difficult matter to explain the uses and working of a machine that few, if any, of the pupils have seen; but with a picture on the screen they will get an idea of the machine and readily understand what is said about it.

The shop work is so planned that one piece of work leads up to the next, the first pieces being comparatively simple, of course, while those that follow are intended to illustrate certain principles the men should get, and at the same time give them the very experience they need.

Practical Letters From Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

A Screw-cutting Attachment for a 13-inch Engine Lathe

As many small screws, both straight and taper, were needed, and as the screw machines in the manufacturing department were too large for the work, I produced the screw-cutting attachment for a 13-inch engine lathe which is shown in the accompanying illustrations. Fig. 1 is a telescope spring chuck with a pull binder sleeve on the outside. Around the binder sleeve and fastened to it with a screw is a 6-inch hand-wheel for the movement of the sleeve forward and back. A 16-pitch thread connects the binder sleeve to the spring chuck. The spring chuck is sawed in three places and has a grip upon the stock 1¼ inches in length.

Fig. 2 is a plan view of the footstock barrel, and shows the turret, turret support and the lever connections for operating the turret. It will be noticed that the footstock-spindle screw was replaced with a shaft having 4 inches of thread on one end and made a sliding fit in a footstock bearing.

Fig. 3 is a face view of the turret with the different tools: turning mill, die and cutting-off tool. The cutting-off tool is shown in working position, the slide-actuating lever, however, being detached. A U-gib holds the slide in place and prevents all dirt and chips from entering its bearing at the end as well as elsewhere. A spiral spring forces the slide back to its initial position after the tool has cut off. A steel-bushed rod support is provided. This rod support is better shown in Fig. 4, which is a side elevation of the turret and turret support. An ejector, plainly shown, forces the screw out and into a pan resting upon the lathe bed after it has been cut off.

Fig. 5 is a section of the turret showing the die and clutch plates as well as the adjusting screw for determining the length of the thread. This die is somewhat out of the ordinary, as it automatically releases itself. It is made to run in a carefully fitted hole and has a clutch upon each end. The inner clutches are right-hand and hold the die while the thread is being cut. When the end of the screw stock comes in contact with the adjusting screw, the die is pulled away from the inner clutch plate until the clutches are disengaged, when the die revolves. On reversing the lathe and drawing back upon the tail-spindle actuating lever, the left-hand clutches bear upon the outer end of the die connected with the outer die plate and cause the die to stop revolving. Openings are provided so that all chips are readily washed out by the stream of oil after the screw is removed from the die. We have had excellent results from this fixture, and yet it is not elaborate. Fifty screws per hour are easily made by one of the "cubs."

Providence, R. I. B. E. CHURCH.

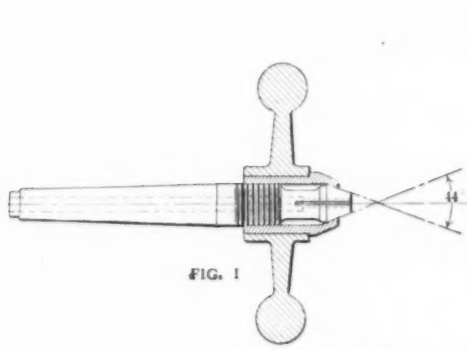


FIG. 1

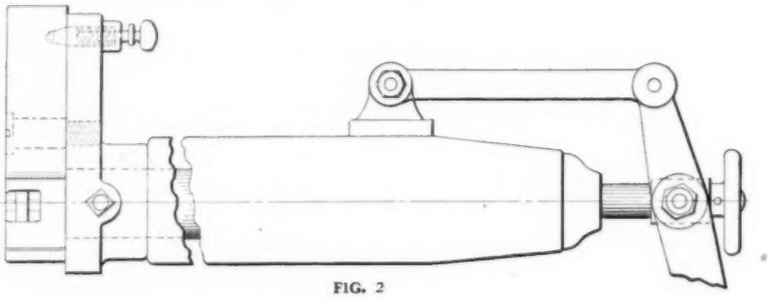


FIG. 2

CHUCK AND FOOTSTOCK FOR SCREW-CUTTING ATTACHMENT FOR 13-INCH ENGINE LATHE

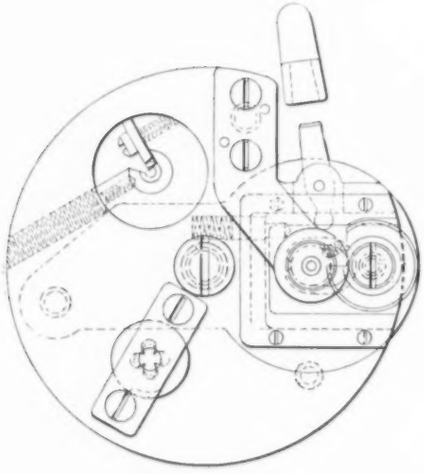


FIG. 3

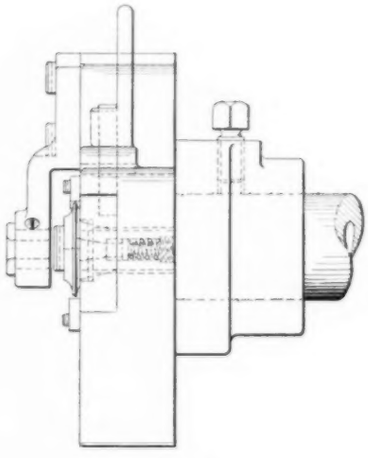


FIG. 4

DETAILS OF TURRET FOR SCREW-CUTTING ATTACHMENT FOR 13-INCH ENGINE LATHE

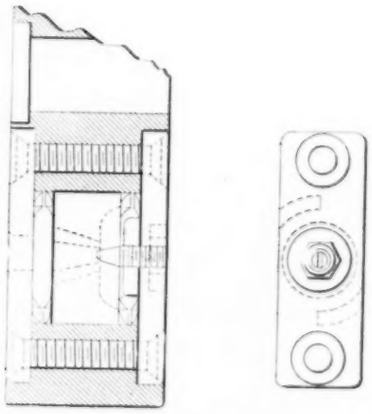


FIG. 5. SECTION OF TURRET SHOWING DIE AND CLUTCH PLATES

Movable Bushings

Mr. Metzroth, in his article at page 594, describes his method of placing bushings in jigs. I am of the opinion that the practice here described will be found to be very satisfactory and more economical.

The movable bushings are made as shown in Fig. 1; there are two outside diameters only as against three in Mr. Metzroth's design. The groove for the stop screw also differs from his, the drawing being self explanatory. The depth of the head of the bush is the same for all sizes.

For a stop we use a shouldered screw made in quantities on the screw machines. The hole for this screw is drilled from a jig, one of these for each size bush hole being kept in the tool room. The head of the stop screw prevents the bush from turning round and also safeguards it against being pulled out of the jig as the tool is returning. We do not use shoulders on our stationary bushes, Fig. 2. We believe a bush of this kind should be a light drive fit in the body of the jig. A shoulder is a loophole for the escape of a loose bush.

The drive bushings, shown at Fig. 3, we use when one operation only is to be performed, as for instance in the case of a rough drilled hole.

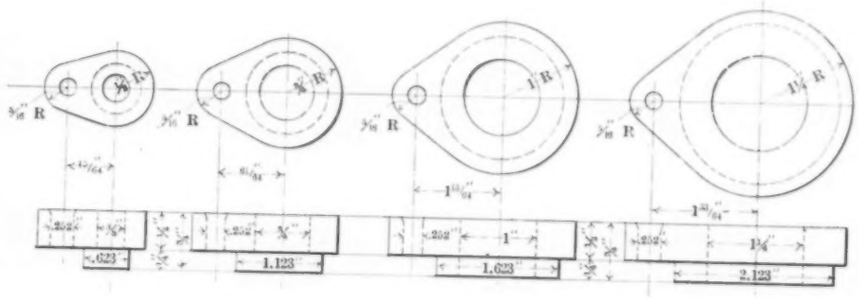


FIG. 5. JIGS FOR DRILLING HOLES FOR BUSHING SCREW HOLES

Removable Bushings

$R = \frac{A}{2} + \frac{3}{16}$

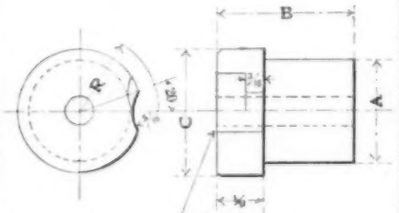


FIG. 1

Size of Finished Hole	A	B	C	Rough Bore	Part Number
0 to 3/32	5/16	1 3/16	1	No Hole	1288
0 to 3/32	5/16	2	1	No Hole	1289
0 to 3/32	5/16	2 3/16	1	No Hole	1290
3/32 to 1/4	1 5/16	1 3/16	1 3/16	5/16	1291
3/32 to 1/4	1 5/16	2	1 3/16	5/16	1292
3/32 to 1/4	1 5/16	2 3/16	1 3/16	5/16	1293
3/4 to 1 1/4	1 5/16	1 3/16	2	11/16	1294
3/4 to 1 1/4	1 5/16	2	2	11/16	1295
3/4 to 1 1/4	1 5/16	2 3/16	2	11/16	1296
1 1/4 to 1 3/4	2 1/16	1 3/16	2 1/16	1 3/16	1297
1 1/4 to 1 3/4	2 1/16	2	2 1/16	1 3/16	1298
1 1/4 to 1 3/4	2 1/16	2 3/16	2 1/16	1 3/16	1299
1 3/4 to 2	2 3/16	1 3/16	2 7/16	1 11/16	1300
1 3/4 to 2	2 3/16	2	2 7/16	1 11/16	1301
1 3/4 to 2	2 3/16	2 3/16	2 7/16	1 11/16	1302

Liners for Removable Bushings

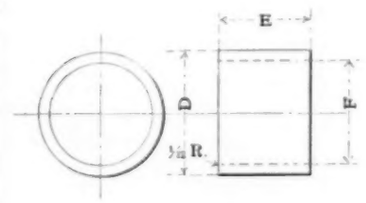
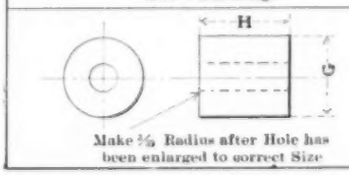


FIG. 2

D	E	F	Part Number
1	1	5/16	1303
1	1 3/16	5/16	1304
1	2	5/16	1305
1 3/16	1	1 5/16	1306
1 3/16	1 3/16	1 5/16	1307
1 3/16	2	1 5/16	1308
2	1	1 5/16	1309
2	1 3/16	1 5/16	1310
2	2	1 5/16	1311
2 5/16	1	2 1/16	1312
2 5/16	1 3/16	2 1/16	1313
2 5/16	2	2 1/16	1314

Drive Bushings



Size of Finished Hole	G	H	Rough Bore	Part Number
0 to 5/16	5/16	3/4	No Hole	1315
0 to 5/16	5/16	1	No Hole	1316
5/16 to 5/8	7/16	3/4	5/16	1317
5/16 to 5/8	7/16	1	5/16	1318
5/8 to 1	1 1/16	3/4	5/8	1319
5/8 to 1	1 1/16	1	5/8	1320

FIG. 3

PROPORTIONS FOR BUSHING BLANKS

Fig. 4 shows a movable bush, stationary bush (or liner) and stop screw assembled.

The jigs referred to for drilling the holes for the shouldered stop screw shown in Fig. 4 are constructed as in Fig. 5. They are tool-steel pieces hardened and ground to fit in the liners (or stationary bushes) and with a hole lapped out to suit the tapping drill for the stop-screw hole.

On our jig drawings we do not show the various bushings; the practice is to

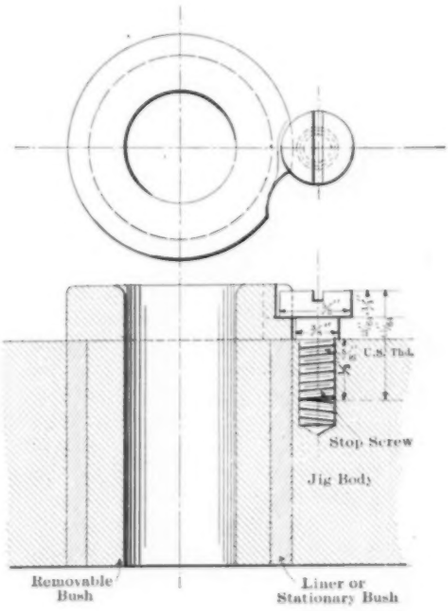


FIG. 4. REMOVABLE BUSH AND SCREW

call for the requisite liners, bushes, screws, etc., giving their part numbers and adding the size of hole required, as for example:

1 liner..... No. 1303.
1 removable bush, drill. No. 1288, 0.235 hole, 15/64
1 removable bush, ream. No. 1288, 0.2505 hole, ¼
1 drive bush..... drill. No. 1318, 0.626 hole, 5/8
1 stop screw..... No. 1274.

It is customary to have the bushes made up on the screw machines, leaving them soft and with grinding allowance—the smaller bushes being left solid. The toolmaker then takes them from stock, finishes them off and fits them to the jig. Where any number of jigs are made, the methods outlined above are highly satisfactory, accuracy and uniformity being attained and not, as is often the case, at increased, but rather at decreased cost.

Cincinnati, Ohio. A. J. BAKER.

Safety Device for Drop Hammers

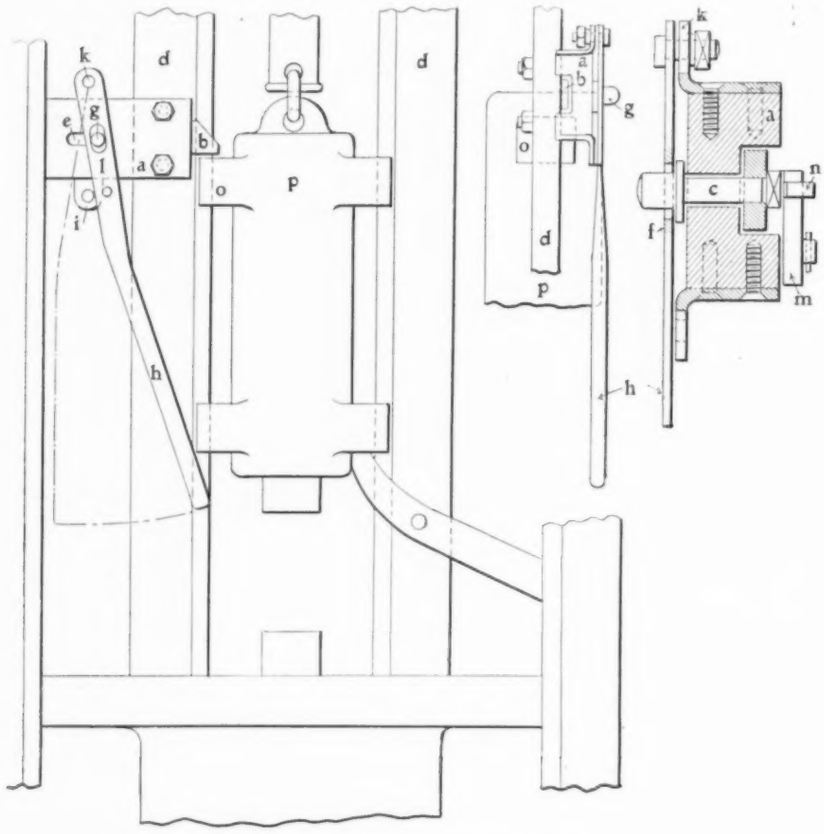
Nearly all drop hammers offer good opportunity for smashing fingers or hands. The arrangement here shown is intended to lessen this danger by furnishing the ram or tup with a locking bolt which must be withdrawn by the workman in charge of the machine. This can be done only by getting one hand out of the way of the tup before the latter can be raised by the other hand. This calls for the workman having both hands engaged in necessary work at points where they are not to be reached by the ram. There is not time enough between the freeing of the ram and its fall to get either hand in danger.

The upper right-hand figure shows a cross-section of the device, and the other two a front and a side view thereof, as applied to a drop hammer. The piece *a*, which is screwed on the guide *d*, guides the end of the bent lever *b*. At the back end this is guided by a pin *c* which is passed through the slot *e* of the guide piece and screwed fast to the bolt. The pin *c*, the flat sides of which run in the slot *e* of the guide *a*, has a disk *f* serving as a washer against the guide piece; its projecting end *g* serves as a grip for the hand lever. This hand lever is connected either with the fulcrum *i* or with the fulcrum *k*; the pin *g* projects through the slot *l*. The spring *m* serves to press the bolt by means of the pin *n*. The workman must manage this appliance with the left hand and the tup with the right. The projecting end of the bolt engages with the dog *o* of the tup, and locks the latter fast. According as the hand lever engages with the fulcrum *i* or the fulcrum *k*, it will by lateral pulling or pressure free the bolt *b* and let the hammer fall. When the hand lever is let go, the spring *m* presses the bolt forward again, and it snaps over the dog *o* of the tup *p*.

The device was originated by Schmidt & Co., Schwelm, Westfalia.

ROBERT GRIMSHAW.

Dresden, Germany.



DETAILS OF DROP-HAMMER SAFETY DEVICE

A Gage for Setting Gear Cutters and Work

At page 388 of the AMERICAN MACHINIST, appears an article respecting the setting of gear cutters central with the work

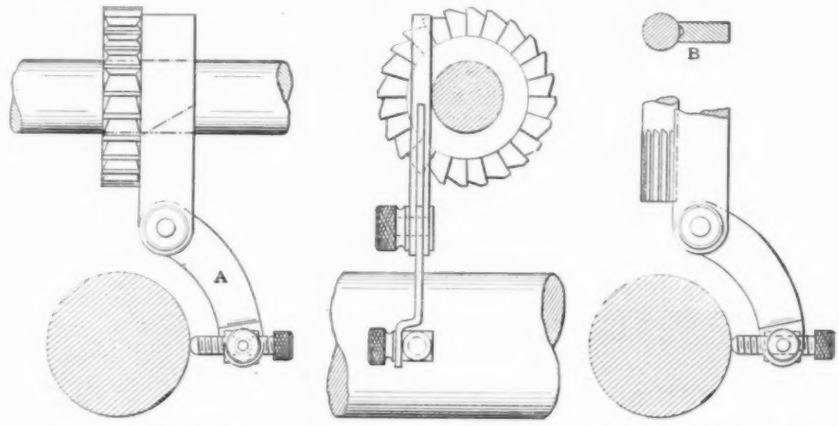


FIG. 1. End Elevation. FIG. 2. Side Elevation. FIG. 3. Gage with V-Stock.

A GAGE FOR SETTING WORK CENTRAL WITH GEAR CUTTERS AND OTHER MILLS

in hand, and accompanying it is a cut of a gage to facilitate the setting. This is a special tool for a special job.

I was reminded, when reading the article, of my own experience when I first took to the milling machine. My first method of setting the work central with the cutter was to place a square on the platen of the machine with its blade in contact with the work and caliper between the upper end of the blade and the cutter, first on one side and then on the other. The cutter, of course, was central when the calipers read the same on both sides. The method of dial reading as described by Dynamic was also used. But after a time I made an extra attachment to my Brown & Sharpe bevel gage No. 483. This is shown in Fig. 1, *A* being the attachment blade. Another elevation is shown in Fig. 2. The stock of the gage is, as shown, placed against the cutter, and the nurled screw is adjusted to make contact on the work with its inner end, which is spherical. The work is adjusted till the screw makes contact alike on both sides.

After a time I made another stock and milled a V down one of its edges. This greatly increased its range of usefulness, as I could then use it to set work central with an end mill or a twist drill. Fig. 3 shows it in use setting work with an end mill. The section *B* shows the V edge.

Birmingham, Eng. WILFRED GEORGE.

Rolled Taps

The Remington Typewriter Works, at Ilion, N. Y., make taps in a way that is new to me. The blank is first made in a screw machine, drill rod being used. The

blanks are threaded with a die and left a few thousandths full. A No. 8 M.S. tap blank would be 0.002 larger, on the threaded part, than finished size. It is then rolled in a thread-rolling machine. This reduces the tap to size and finishes the threads. The threads on the rolled blanks are smoother than any I have seen cut with a tool. The manager says they are the most satisfactory taps they have ever had.

New York, N. Y. E. A. DIXIE.

Sector for Dividing between Holes in an Index Plate

The accompanying sketches show a sector for use on dividing-head plates and a device for dividing between the holes in the plate. Fig. 1 is a front and Fig. 2 a side elevation, with a small section shown through line *a b*.

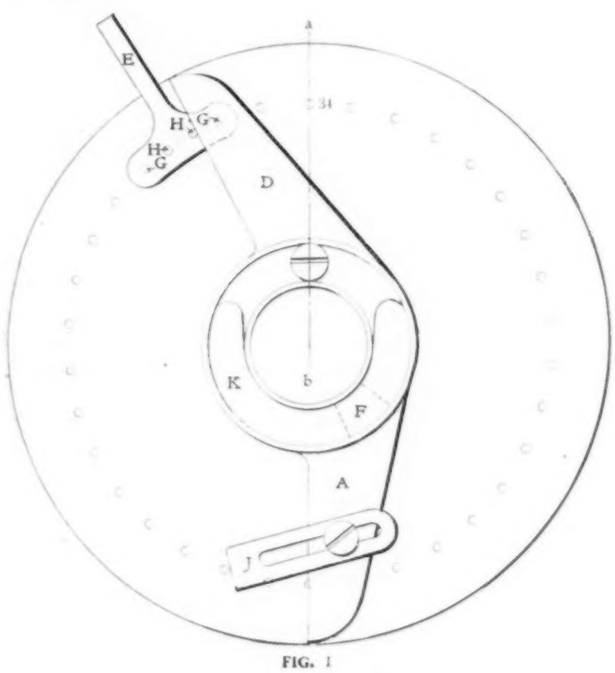


FIG. 1

FIG. 2

STANDARD DEVICE FOR DIVIDING BETWEEN HOLES

The sector blade *A* has a dovetailed groove cut in its outside face to fit the small plate *B* and has a hole *F* cut to allow the plate *B* to be put in its place. The upper sector blade *D* is flat on its under side and clears the plate sufficiently to pass over the spring dividing plate *E*. It has a hole drilled through its hub for the plate *B* and a shallow groove turned in its hub to retain the friction spring *G*. The two blades are fastened together by the screw *C*, which passes through the small washer shown and screws into the plate *B*, binding them all together firmly.

The plate *B* is about a 30-degree section cut from a ring.

The spring dividing plate *E* has two short pins *G G*, which fit into the holes of the dividing plate, and two holes *H H*, which divide into three spaces the two spaces between *G G* in the dividing plate, making it possible to subdivide the regular divisions of the plate.

The stop *J* is clamped to the sector blade *A* as shown and, like the sector blade *D*, is made to pass over the spring dividing plate *E*. The sector blades *D* can be turned entirely around by removing the screw that holds the stop *J*. In the sketch the device is set to 12⅓ spaces. To make 51 divisions on the 34 circle shown, the sector blade *D* and the stop *J* must be set to 26⅔ spaces.

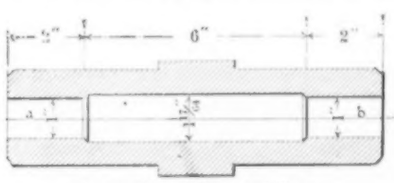
In use the stop *J* is brought against the pin in the dividing-head arm each time before the spring dividing plate *E* is moved to its next position. After the division is made, the pin is drawn from the hole; but the arm is not moved till the spring dividing plate *E* is moved to its next position.

The sector without the stop *J* and the spring dividing plate *E* (which can be varied in its spacing to suit the requirements) is used for regular work and with these attachments for unusual dividing.

Watervliet, N. Y. M. H. BALL.

A Tool for Recessing Long Work in the Turret Lathe

We had about 2000 pieces to make, illustrated by Fig. 1, and we decided to do them on a Jones & Lamson turret lathe. The castings were of bronze and had to be recessed in the center. At *a* was a right-hand ¼-inch pitch thread and at *b* a left-hand thread of the same pitch. We tried to recess them with an ordinary stiff boring tool; but as this did not give good results and as we had such a large number to do, I designed the special bar shown. This bar gave us excellent results



Section through Center of Piece to be recessed

FIG. 1. THE PIECE TO BE RECESSED

and proved a time saver. The bar *A*, Fig. 2, was turned from machinery steel 0.0005 inch smaller than the diameter of the holes *a* and *b*; the larger end was made to fit the turret. Through the center of the bar a ⅜-inch hole was put to take the cam bars *C C'*, which were made of ⅜-inch drill rod. A spiral spring *D* pressing on the rod *C* pushes the cutter *B*, Figs. 2 and 3, back in place after it has done its work. The grub screw *E* holds the spring in position. Another screw *F* provides means by which the cut is put on. It is provided with a split collar *G*, Figs. 2 and 4, by which the depth of the cut is determined, and is provided with a hand wheel *H* (in this case taken from a

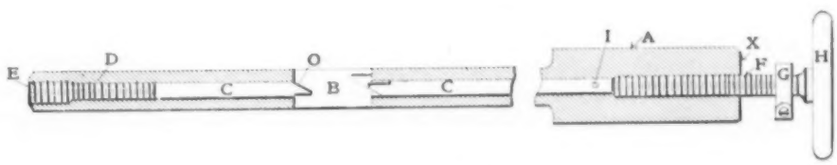
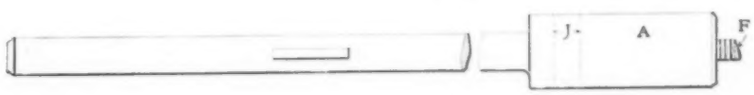


FIG. 2



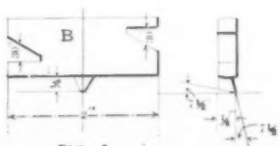


FIG. 3

FIG. 4

FIG. 5

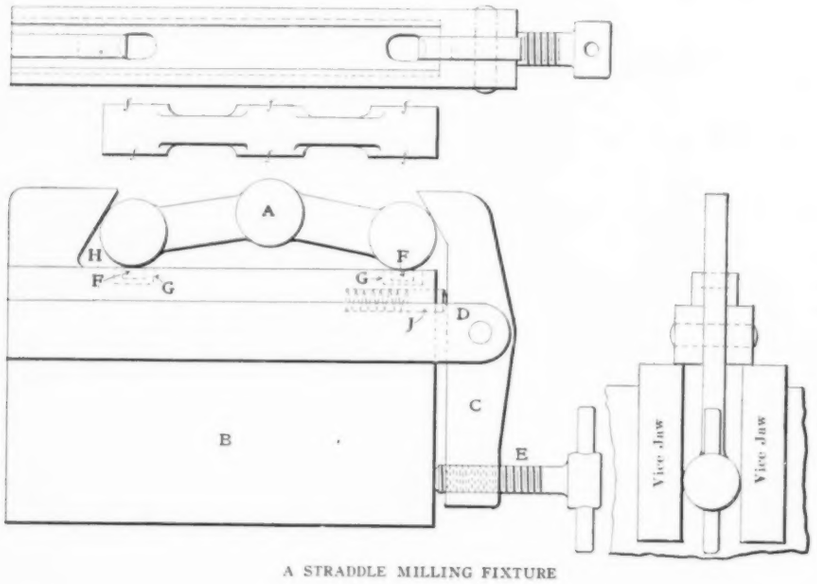
A TOOL FOR RECESSING LONG WORK

disused stop valve) with a square hole, a sliding fit on the shank of the screw. A 3/16-inch parallel pin is at *I* to prevent *C'* from revolving when the screw *F* is turned. The setting gage by which to set the cutter *B* to the correct depth is shown by Fig. 15. To set the cutter this gage is made to rest on the bar *A*, and the screw *F* is advanced, bringing out the cutter *B* until it touches the gage; the collar *G* is then brought up to the face *X* and locked. For setting in the turret, the wheel *H* is removed, the bar is put through the turret and the wheel *H* is slipped on again. In using this bar, we removed the stock in two cuts, leaving a cleanly finished and accurately sized recess.

London, England. J. P. Essex.

A Straddle-milling Fixture

The illustration shows a cheap and serviceable fixture for straddle milling the sides of the cast-iron lever *A*. It is designed to be held between the vise jaws, and consists of a machine-steel body *B* carrying a clamp *C*, pivoted at *D* and actuated by a screw *E*. The work is located sideways by the small bosses *F F* resting in the slots *G G*, and is securely held in the V *H* by the clamp *C*. A spring-actuated plunger *J* is provided to push clamp *C* away from the work when screw *E* is slacked back.



A STRADDLE MILLING FIXTURE

This proved a speedy and reliable device and enabled the time previously taken on these parts to be reduced by one-third, at the same time producing a much better job. Of course the body *C* could be provided with a base and clamped in the usual way to the machine table, but at the time the pieces were required it was not possible to wait for a casting and the vise served the purpose equally well.

Marquette, Mich. S. W. Mills.

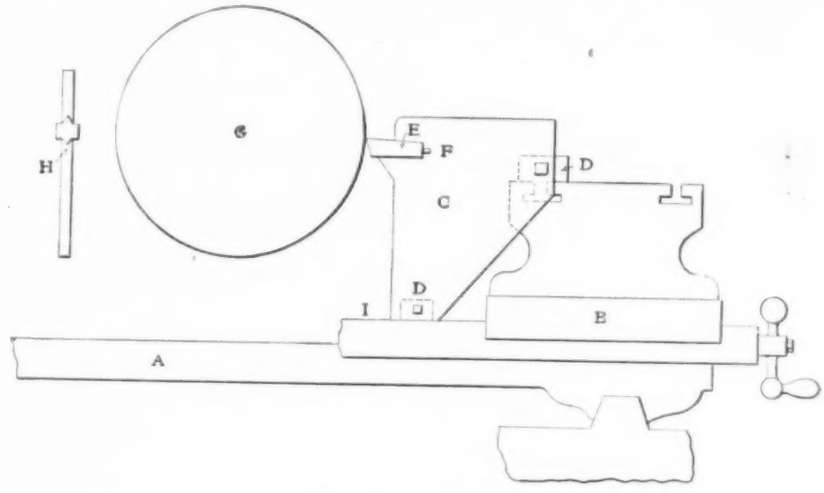
A Novel Cutting-off Tools

The question of cutting up old cast-iron guns of large caliber, 11-inch and others, so that the material can be handled in the foundry, has been a hard one to solve. It remained for the tool-room foreman, Frank Soverien, in the department of steam engineering, Mare Island navy yard, to show the "easy way."

C is a steel plate, 9/16 inch thick, bolted to angle plates *D D*, which are in turn bolted top and bottom to the cross slide, and with the bed of the plate resting solid at *I*. There is a V-shaped slot (see *H*) cut in the plate, and a high-speed tool-steel, square-nosed tool ¾ inch wide on the cutting edge is driven in. *F* is a hole for drifting out the tool for grinding. *G* represents the gun. The work is done in a 60-inch lathe. The breeching jaws are held in a chuck, and a centering piece is placed in the muzzle. The gun also revolves in a steady rest.

This tool will cut off stock 36 inches in diameter, although in these old guns it cuts in about 15 inches. The tool is cheap, quick and successful.

Alameda, Cal. Walter de Sanno.



A NOVEL CUTTING-OFF TOOL

Making Dies for Plastic Material

I have been very much interested in the discussion which has arisen on this subject, especially as my article "Making Low-priced Impression Dies" was the beginning of it all. Dixie's criticism of this article on page 415 was certainly very hard; but I magnanimously forgave him because I knew he did not know all the facts of the case, and I let it pass. F. L. C. George, in his practical and complete description of the process of making dies by hydraulic pressure was very instructive; I would like to ask him what is the largest area of impression he has been able to make, or the largest amount of metal he has been able to displace with a 200-ton hydraulic press.

E. A. Dixie, on page 808, again brings up the question of cheapening the die I wrote about; so I wish to call his attention to the fact that the die shown was only one of six pairs that composed each mold. This die was the simplest one of all, and yet it had a very complicated raised design upon its surface which certainly would have cost considerably more to produce in the male form than in the female form, which would have made a big difference as it had to interchange with twenty others of different design. Still the initial cost of one die of each kind would have been almost negligible if it had been possible to use Dixie's method. However, this method was tried on that particular die, using aluminum blanks, and it was found impossible to obtain sharp, clear results in one squeeze, or even more, although a hydraulic press of an alleged 500-ton capacity was used. We might have been tempted to experiment along this line further had it not been for the fact that two of the dies in each mold called for a female die with

a special-shaped recess 4½x4x1 inch deep with two male dies to match; it seemed to me to be an impossibility to squeeze this shape in even the softest machinery steel without shearing and tearing the edges, as there were some 90-degree corners in the recess. We never actually tried this, but even after reading about Dixie's sphinx head (the die head, not Dixie's), I do not believe it could be satisfactorily accomplished at the price we were able to produce them by electro-deposition.

Buffalo, N. Y. GEO. P. PEARCE.

Is the Inverted-V Type of Lathe Bed All Wrong?

The editorial, on page 532, on the subject of lathe beds, should be of interest to all machinists and toolmakers who have worked on both sides of the Atlantic. The quotations from Professor Nicolson's articles show in a decided manner the prejudice against the American type of bed among those Englishmen who have not worked on a large variety of tools in both countries. I learned my trade in England and have worked on all kinds of English tools from the highest class down to tools which I would not accept as a gift to run in my own shop. Similarly I have worked some years in the United States on tools from the best makers and on tools upon which the makers were ashamed to put their names. I shall attempt to present without bias my views of the two types.

In any straight-line motion, when one member of the machine guides another by a surface and sliding contact, the deviation of the sliding member from the straight path is less if the guiding surfaces are narrow and long. This is the ideal upon which the inverted-V bed is constructed, and it is theoretically correct. As the V's of the bed and saddle wear, the saddle drops vertically downward. This does not cause shake in the saddle, nor allow of any play or twist in a horizontal direction, because the angle of the sides of the V's is acute, and the weight of the saddle and the downward pressure of the cut are so great that the saddle cannot lift from the ways. Thus, through wear, the saddle of the American type of lathe is deflected from the straight line in one direction only, namely, downward.

The flat-top lathe bed is affected very differently by wear. The large flat top of the bed and the bearing surface of the saddle wear downward in this case also, but the most wear is on the underneath V-slides of the back and front ways of the bed and saddle, as shown exaggerated in Fig. 1. In this case it will be seen that there is not only downward wear, but also wear of those important guiding surfaces which limit the horizontal shake in the saddle. With this type of lathe it is necessary to keep the saddle carefully adjusted or the V-ways of the saddle become curves instead of straight surfaces, and all hope of straight turning is lost. I remember one English lathe in this condition in which a feeler 0.010 inch thick could be pushed between the V's of the saddle and the bed at one end, when feeding in one direction, and at the other end when the feed was reversed. Moreover, the effect of horizontal slack in the American lathe is less on the tool and consequently on the work than in the English lathe, for in the former the tool is nearly in the center of the saddle, while in the latter the tool is near the forward end and is thus much farther away from the center of "rock" of the saddle, as shown in Fig. 1. It is almost unnecessary to point out that horizontal deviation of the tool from the true straight line is much more serious than vertical drop. In the former the error doubles in the diameter of work, whereas in the latter case the tool must drop many thousandths (except on work

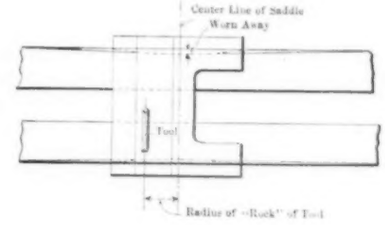


FIG. 1

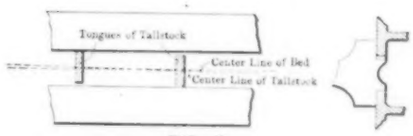


FIG. 2

POINTS OF WEAR OF THE ENGLISH TYPE OF LATHE BED

of very small diameter) to cause an error of even 0.001 inch in the work being turned.

When we consider the tailstock, the case for the American type of inverted V is even better. A tailstock guided on V's can have no horizontal play; it can only wear out of line downward, and the effect on the work is little; for no matter how far out the barrel may be the centers are in line with the ways. On the other hand, as shown in Fig. 2, the English tailstock, guided as it is by tongues in the interior parallel ways of the bed, wears out of line horizontally and the wear cannot be taken up. It is the practice of English turners when working on old lathes to grasp the tailstock at both ends, push with one hand and pull with the other before tightening it down. Even then the error is not eliminated, for the barrel is on the "skew" with the ways; and if the centers are adjusted to turn parallel when the barrel is out one inch, the lathe will not turn parallel when it is out three inches. On one English lathe I was obliged, when doing heavy work, to drive wedges between the tongues and the ways to keep the tailstock from creeping out of line. In this case it was not possible to tighten the tailstock firmly on account of the springing of the bed, so that the saddle worked hard when near it.

From these remarks some readers will think that I am prejudiced, and I wish to remove that idea by adding a few opinions on the lathes of both countries. It seems to me that the makers of the two countries reverse the order of certain points aimed at in the design and construction of lathes. English makers seem to consider, first, durability; second, accuracy; third, handiness. American makers seem to consider, first, handiness; second, accuracy; third, durability. Accuracy is placed second on the two lists, but I consider that the average American lathe is more accurate than the average English lathe. The cone-bearing spindles so general on high-class English lathes are superior to the parallel-bearing spindles of American lathes as regards freedom from chatter, turning work round, ease of taking up the slack and ability to keep true as they wear. But English spindles should be made hollow as are the American.

The English method of raising the number of teeth in change gears by fives, as 20, 25, 30, etc., is more convenient for calculations in thread cutting than the system here. Also the coarse pitch lead screws (two to the inch) are convenient when cutting long screws, as the saddle can be turned by hand and the nut dropped anywhere for screws with an even number of threads; it is only necessary to chalk the catch plate and lead screw to drop the nut with ease for odd threads. The inaccuracy resulting from wear is less and they are more quickly cleaned.

I consider that the English compound rest is superior to any I have seen on this side. But the strongest point about English lathe design in comparison with American is the method of holding the tool. The English method is rigid; it is not necessary to use bent tools when working close to the chuck; and it is theoretically correct, for the tool angles are preserved, which is very important when using form tools. The American makers sacrifice rigidity (which means also the efficiency of the cutting tool) and theoretical accuracy in order to gain a few seconds (?) every time the tool is removed or inserted. Finally, my remarks apply only to small and medium-sized lathes, as I have had no experience on lathes above 24-inch swing. It seems to me a pity that Professor Nicolson should have so severely criticized what is really one of the best features of the American lathe, and one which, if added to the English lathe, would vastly increase its accuracy.

Toronto, Canada. F. J. B.

AMERICAN MACHINIST

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Jan. 2	37,500
Jan. 9	20,000
Jan. 16	20,000

This paper reaches 37,500 *separate readers each month and* 20,000 *each week.*

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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Instructions for Foremen

All of our great railroads have carefully prepared codes of rules and regulations printed in book form, distributed among their employees and forming a basis of operation for their vast systems. Why should not a similar instruction book be prepared and used in our great machine-manufacturing plants to give detailed information to the executives, superintendents and foremen?

Too often the following condition is met with: A foreman is hired for a particular department in a large factory. On the morning of the day when he is to go to work the superintendent or general foreman takes him for a stroll through the plant and introduces him in a more or less offhand way to other foremen with whom he is to come in contact. He is then brought around to his desk or headquarters, a wave of the hand indicates his department and he is left to his own devices. If he is an experienced foreman and desires to keep himself out of trouble, he will spend the first two or three weeks in hunting around and asking questions, trying to learn the factory's system; if he is a more or less inexperienced man in foremanship, he will probably try to run his job and let the system find him.

Either condition is unpleasant, is a hardship and should be entirely unnecessary in a well organized shop. As there is no uniformity whatever in factory systems, and probably never will be, experience gained in one place can be of nothing more than the most general value in another. Each establishment has its own method of time keeping, ordering and charging material, caring for machine tools and small tools, payment of wages, handling of assignments, etc. We are offering no criticism on these methods, for they undoubtedly serve in the places where they are used; but a new man coming into the plant in an executive position knows nothing about them and rarely, if ever, receives detailed, complete and proper instructions when he starts.

It is doubtful if a single man, from the works manager down, can be found in many manufacturing plants who is able to define clearly all of the details and methods of the entire factory system. Very often a new scheme is started in a way something like this: It is, we will say, desired to change the method of keeping time, possibly from the older form of time sheets to the newer form of time cards. In order that this system may be put in operation on a certain day, the office manager prepares mimeographed copies of detailed instructions to all the foremen. These instructions have hardly reached the foremen's desks before another sheet is sent around, amending, nullifying or enlarging some of the provisions of the original set. At the end of the first week's use some points have apparently been overlooked and another series of instructions is sent out; from time to time as other points develop, other changes are made, usually without the formality of a written notice, and in time the systems and methods become crystallized for that particular place. No complete record exists and it is doubtful if anyone could gather together the various instructions which have been issued and piece them into anything like a consistent whole. Is it not surprising that the foremen do as well as they do in caring for the general details of the business of their department?

Should a factory prepare a careful code of instructions covering all of the systems throughout the organization, it would not only serve the purpose of affording a book of reference for the executives, but it would also aid in establishing uniformity and consistency at the points where one part of system comes in contact with another.

Expense Analysis

A factory overhead burden is a difficult thing to control and to proportion properly as a part of the cost of a manufactured product. It is made up of many factors, some of which are constant from month to month, or year to year, while others vary greatly with the condition of business and of factory operation. The fixed charges, as interest, insurance, taxes, and depreciation, do not vary to any great extent. The elements of expense, supplies, repairs and unproductive labor may vary widely, however, from year to year, or even from month to month, or week to week.

Many methods are used for distributing the gross expense burden. Some use a fixed charge on each productive hour's work in the plant; others use a flat percentage on productive labor. In some cases this expense is watched with the utmost care and a detailed statement prepared each week in order that it may be studied and reduced to a minimum. In other cases a monthly statement is considered sufficient, and in still other cases an analysis once in six months or once a year is all that is deemed necessary. It is, however, of the utmost importance, and if business conditions result in the reducing of the number of productive hours, it is very easy for the ratio of the overhead burden to the productive labor to rise; this fact must be taken into consideration in determining the cost of product made under such shortened conditions.

It is not always the large factory which has an advantage in this respect. Oftentimes the smaller plant has a much less relative expense burden than a larger neighbor. We have knowledge of one plant which in 1893 employed about 300 men and had an expense rate of $0.07 per hour on each productive hour worked. In 1906 this plant had grown until it em-

ployed 3000 men and its expense rate had increased to 120 per cent. of the productive labor. The line of machinery manufactured was the same except on a much enlarged scale. Undoubtedly the change in business conditions throughout the period had its influence upon this situation as well as the great increase in capacity. Still, whether the factory be small or large, the overhead expense should be watched at all times by detailed and frequent analysis and especially so under unusual business conditions.

George H. Reynolds

George Huntington Reynolds, the well known mechanical engineer, died at his home, Spring Manor, Mansfield Depot, Conn., Jan. 3, 1908, aged 79.

He was born in Mansfield and when quite young showed signs of mechanical genius which later on placed him in the front rank in his calling. He began active work as a spinner in woolen mills. While employed in this capacity at Merrow, Conn., his first mechanical work was done. As a result he left Merrow and went to Leominster, Mass., where he devoted his time to steam engineering. In 1856 he exhibited a steam engine of his own design at the American Institute Fair, held at Crystal Palace, New York, for which he received a gold medal and the following year was made superintendent of the fair. In 1859 he became chief draftsman of the Delamater Iron Works and three years later was made superintendent and general manager of the Mystic Iron Works, Mystic Bridge, Conn., a shipbuilding yard during the Civil war.

After the war he returned to the Delamater works as superintendent, which position he held until 1884, when he resigned to assume a similar position with the Crane Elevator Company, of Chicago.

As consulting engineer of the Pneumatic Dynamite Gun Company, of New York, he superintended the construction of the dynamite cruiser "Vesuvius" and the dynamite guns built for various governments. As an inventor he was very successful, having taken out over a hundred patents for various mechanical devices.

New Publications

POWER STATIONS AND POWER TRANSMISSION. By Geo. C. Shaad. 74 6½x9½-inch pages; with 84 illustrations. The American School of Correspondence, Chicago. Price, $1.

This book may be described as a review of current approved practice in the construction of power stations and power transmission lines. It gives many typical layouts and plans of standard apparatus, together with illustrations of power stations. The section on power transmission relates to both the electrical and mechanical features of transmission lines. It is mildly mathematical, but nevertheless simple in comparison with many other discussions of the subject. While not intended for experienced experts in the lines covered by the book, it may be recommended to others as a useful and satisfactory presentation of its subject.

RAILWAY SHOP UP TO DATE. Compiled by the editorial staff of the *Railway Master Mechanic*. 238 pages, 9x12 inches. Fully illustrated. Published by the Crandall Publishing Company, Chicago, Ill. Price, $3.50.

This collection of material should be of great help to any railroad mechanic who has to do with shop lay-out or operation. It shows in detail a large number of plans of shops on various roads, gives suggestions for machine-tool equipment and much other valuable information that can be obtained in no other book that we know of. It seems to cover all the departments, including power houses, oil houses, foundry and pattern shops, while photographs show more plainly than words how the material is stored at different shops. The only objection to be raised is with the title, which has been overworked and which can never be strictly true of anything but a periodical.

THE STUB-TOOTH GEAR. 23 6x9-inch pages; 21 illustrations. Fellows Gear Shaper Company, Springfield, Vt.

This pamphlet is issued for gratuitous distribution. Of late years gear teeth shorter than the so-called standard have come into more and more use in automobile and machine-building industries. This pamphlet explains the advantages of the combination of a short gear tooth with an increased angle of obliquity. It explains and illustrates by numerous diagrams the advantage of lessened interference, of a decreased ratio of the actual to the maximum arc of action and of the increased strength of the tooth to resist fracture. These points are clearly set forth and should prove of interest to users of gears. It is brought out at an opportune moment when much study is being given to tooth action and the proportions and material for gears in general. A short table is also included, giving the tooth dimensions of the stub tooth.

A POCKETBOOK OF MECHANICAL ENGINEERING. By Charles M. Sames. Third Edition. 195 4x6½-inch pages, with 40 illustrations. Charles M. Sames, Jersey City, N. J.

We have already noticed the first and second editions of Mr. Sames' Pocketbook, the chief characteristic of which is its extreme compactness of statement and the immense amount of ground covered in comparatively small space. The call for a third edition within two years of the original appearance of the book indicates that there are many who prefer a pocketbook of this character. The material which appears in this edition for the first time includes the leading results of F. W. Taylor's experiments on speeds and depths of cuts for high-speed tool steel, tables giving results of the latest researches on superheated steam, formulas for beams, and columns of reinforced concrete, and additional material on the subject of machine design.

Personal*

Walter B. Snow, publicity engineer, Boston, has been elected president of the alumni association of the Massachusetts Institute of Technology.

William Banghman, formerly superintendent of the General Electric Company at Pittsfield, Mass., is now in charge of the supply department.

Carl Barnum, foreman toolmaker of the Triumph Voting Machine Company, is to spend the winter in the Adirondack mountains on account of ill health.

D. C. Fenner has relinquished the position of division superintendent with the Sayles Bleacheries to associate himself with the Knox Automobile Company, New York City.

Aldrich Durant, superintendent of the Turner Construction Company, has recently assumed a similar position with the Raymond Concrete Pile Company, New York City.

W. K. Millholland, who has been connected with the Gisholt Machine Company, has accepted the secretaryship of the International Machine Tool Company, Indianapolis, Ind.

Mr. Sponsel, formerly connected with the Pratt & Whitney Company, has recently been appointed superintendent of production of the General Electric Company's Pittsfield plant.

Rutgers S. Kasson, who held the position of treasurer of the Finch Anderson Construction Company has organized and become president of the Kasson Contracting Company, Glen Falls, N. Y.

Gorham C. Parker, for some time past in charge of the selling department for Jacobs chucks has recently been appointed sales manager of the Wm. J. Smith Company, New Haven, Conn.

Merritt M. Pharo, formerly superintendent of the Mianus Motor Works, has severed his connection with that company and is now engaged in the manufacture of an improved type of gas engine, with headquarters at Greenwich, Conn.

Charles H. Norton, representing the Norton Grinding Company, Worcester, Mass., sailed from New York on the steamer "Celtic," which departed January 9. Mr. Norton expects to remain abroad three months in the interests of his company.

*Items for this column are solicited.

New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make It Possible To Do Better Work at a Reduced Cost

THE LATEST INFORMATION

New Motor-drives for Lathes and Milling Machines

The results of the recent easing up in immediate demand is beginning to manifest itself in the bringing out of new tools which have been kept in the background, and among the first are the new motor-driving mechanisms of the R. K. Le Blond Machine Tool Company, Cincinnati, O., one of the pioneers in the development of the constant-speed drive.

The general arrangement of the 24-inch lathe which has just been brought out is shown in Fig. 1, with a variable-speed motor over the headstock. The motor can be controlled from the carriage by the small crank at the right, which connects with the lower rod in front of bed, across the end by chain and sprocket to a rod on back of bed. The changes of speed due to gearing in the head are controlled by the lever in the headstock. Fig. 2 is the arrangement of headstocks for lathes under 24 inches and shows the motor control from carriage, the clutch on end of motor shaft and the lever for controlling changes in the head. Fig. 3 shows the arrangement of gearing for lathe heads up to 22-inch swing, where the drive from the motor is through the clutch pinion on the end of the motor shaft, a rawhide intermediate gear and the sleeve gear on the spindle. This sleeve gear can be locked to the face gear for direct speeds or the drive can be through the double friction back gear in the regular way. This pinion is shown at the bottom, but is really at the back and controlled by the lever in front of the head. There is also a clutch in the motor pinion, controlled by the lever at the end of motor shaft, so that the motor can be connected or disconnected at will. This is for constant speed, alternating-current motors.

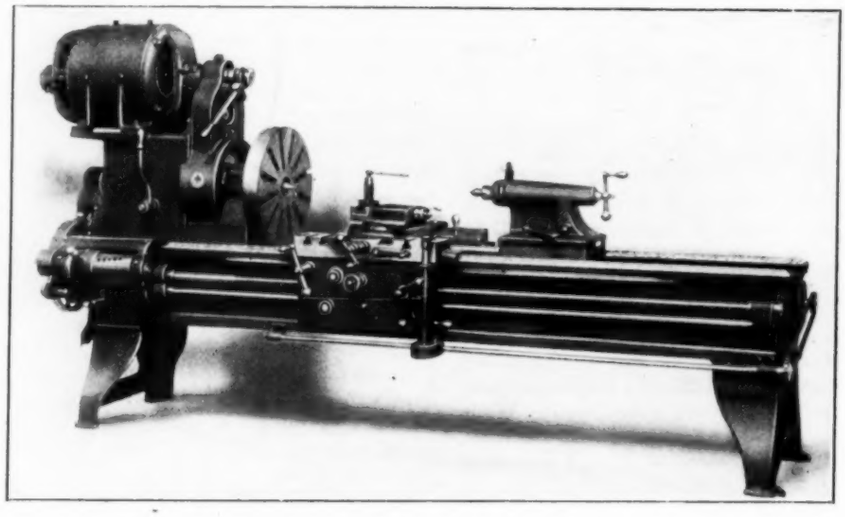

FIG. 2. LATHES BELOW 22-INCH HAVE THIS DRIVING HEAD

The greater speed range required by the larger lathes requires some modification of the construction as shown in Fig. 2. Here there is a double friction shaft mounted in the housing for the motor,

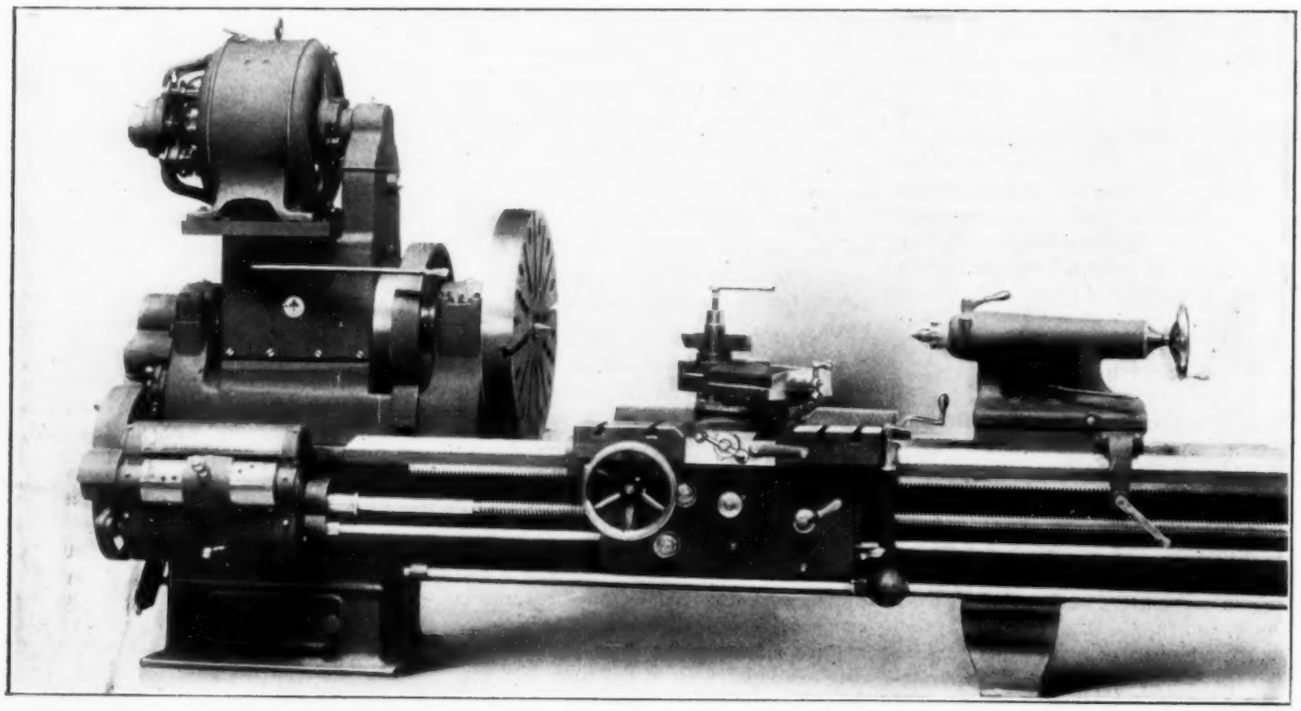

FIG. 1. 24-INCH LATHE WITH VARIABLE-SPEED MOTOR DRIVE

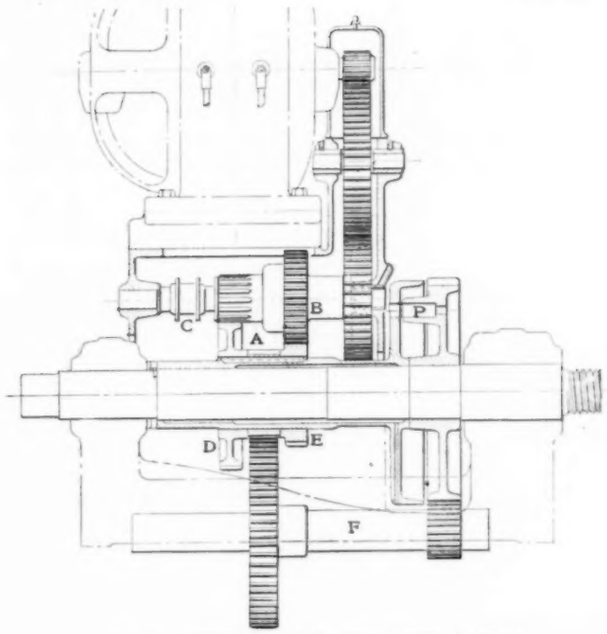

FIG. 4. DRIVING GEARS FOR LARGER LATHES

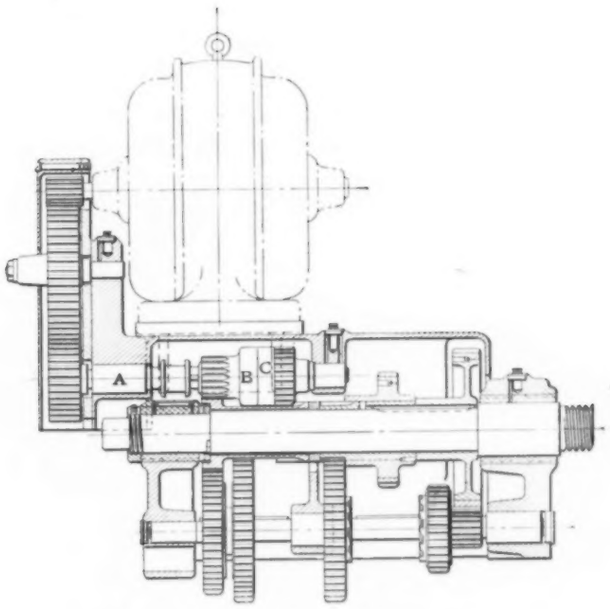

FIG. 5. HEAD FOR CONSTANT-SPEED DRIVE

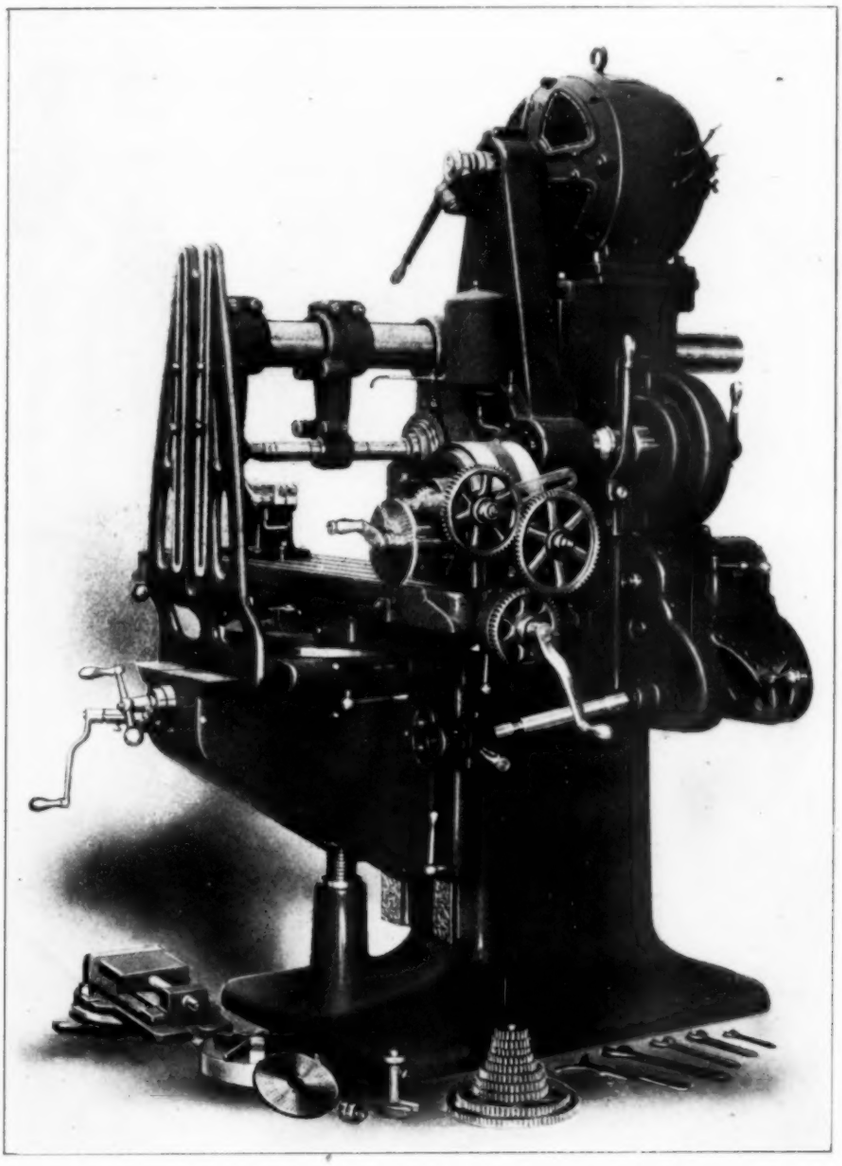

FIG. 6. UNIVERSAL MILLING MACHINE WITH CONSTANT-SPEED MOTOR

over the spindle and driven by the rawhide gear, giving four mechanical changes of speed in addition to those obtained in the smaller-sized lathes. See Fig. 4.

The clutch operated from *C* makes either *A* or *B* the driver, the gears *D* or *E* drive the spindle through locking pin *P* and the other two changes come from the back gear *F*, shown below.

For milling machine the same general plan is followed, except that a Morse chain is used to drive from the motor, instead of gears, on account of the over arm being in the way.

To allow the alternating or constant-speed motor to be used in places where more convenient they have also developed drives to accommodate this for use in both lathes and milling machines. Fig. 5 shows a headstock to be run in this way. The motor drives through a rawhide intermediate to the shaft *A*, carrying the double friction gears *B* and *C* of their standard, automatic adjustment and which are operated by a convenient lever. These give two changes of speed as well as control of the lathe independent of the motor.

On the lower shaft is a set of sliding cone gears which multiply the speeds and give twelve speed changes in all, without the usual back gears or lock nut between face gear and cone. All the gears are made of steel and, with beveled edges to the teeth and are all hardened. The gears which run at a high speed are held by the jaw clutch shown at the right. These give a speed range of from 10 to 270 revolutions per minute.

This same plan, with necessary modifications, is used in the milling machine drive, and here they are arranged for a wider range of speeds than in the lathe, running in steps of 22½ per cent. from 13.8 to 374 revolutions per minute. Fig. 6 shows the latest milling machine of this

type with induction motor and chain drive. Fig. 7 is a constant-speed belt-driven plain milling machine built for heavy work.

Those who are interested in the economies of motor driving should consult the new publication on this subject which this company is about to issue, as it gives the results of a number of interesting tests having a direct bearing on the subject.

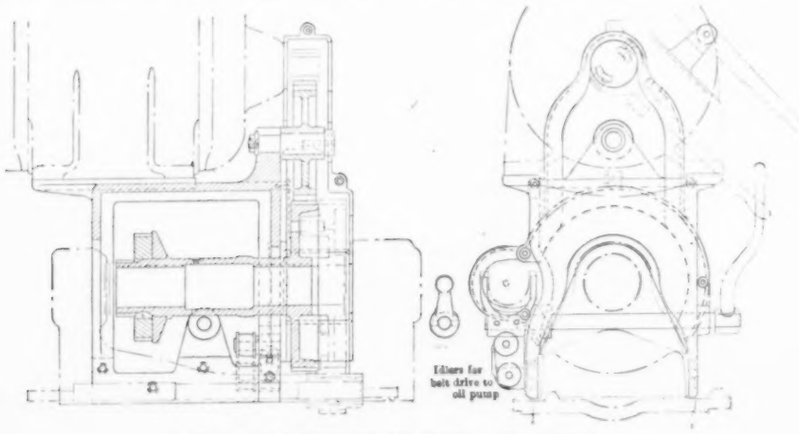

FIG. 3. DETAILS OF 20-INCH LATHE HEAD

How Can Technical School Shops Do Commercial Work?

By J. H. Gill*

There are a large number of technical schools that are equipped with shops capable of doing a good deal of work on a commercial scale. These schools are often supported by the State and there is serious objection to the work from these shops coming into competition with that of regular mechanics who are making their living by their work. In fact this work is looked on very much as that from prisons.

The foundry is perhaps the department which could do more of this work than the other shops of the schools as now operated. We must make castings. With patterns that are correct, there is no reason why a large per cent. of the castings made could not be used. The foundry makes more castings than can be used in the machine shop of the school. The result is that they accumulate and are remelted. Much is lost in this way and the quality of the iron deteriorates. Besides, no student will take as much interest or do as good work if he knows it is to be broken up, as he will if he knows it is to be put to some practical use. School shops cannot introduce commercial methods largely because they cannot use the product of machines which make duplicate work. If we could put in automatic machinery and use jigs, templets and limit gages in our machine shops, drop hammers and forging machines in our forge shops, molding machines, core machines and cleaning machinery in our foundry, and up-to-date pattern machines in our pattern shops, and use the product from these machines or as much of it as would pass a rigid inspection, we would be able to give our students a more thorough training in the modern methods of shop work and at the same time help to pay for this addition to our equipment.

The University of Illinois tries to do something in this line by having several designs for small gasolene engines. A full set of patterns for these engines is in the foundry. The pattern work of the students is made up largely from these parts. The foundry consists in a large part of making castings for these engines. If the student pays for the iron in a set of these castings, he may use a large part of his machine-shop time to finish them up; when finished to the satisfaction of the instructor, the engine is his to take away. He must do a certain amount of preliminary work in the machine shop and do it in a satisfactory manner before he is allowed to begin an engine. This gives the student something to work for, and the result is that students, in the machine shop particularly, take a great interest in their work. Many put in extra time on their own account, and it is the usual thing for students to stay and work till the shop has to be closed for the night. The result is so satisfactory that we would like to extend the scheme.

I think here is a chance for an interesting series of articles from both teachers in school shops and others.

*Assistant professor of machine construction, University of Illinois.

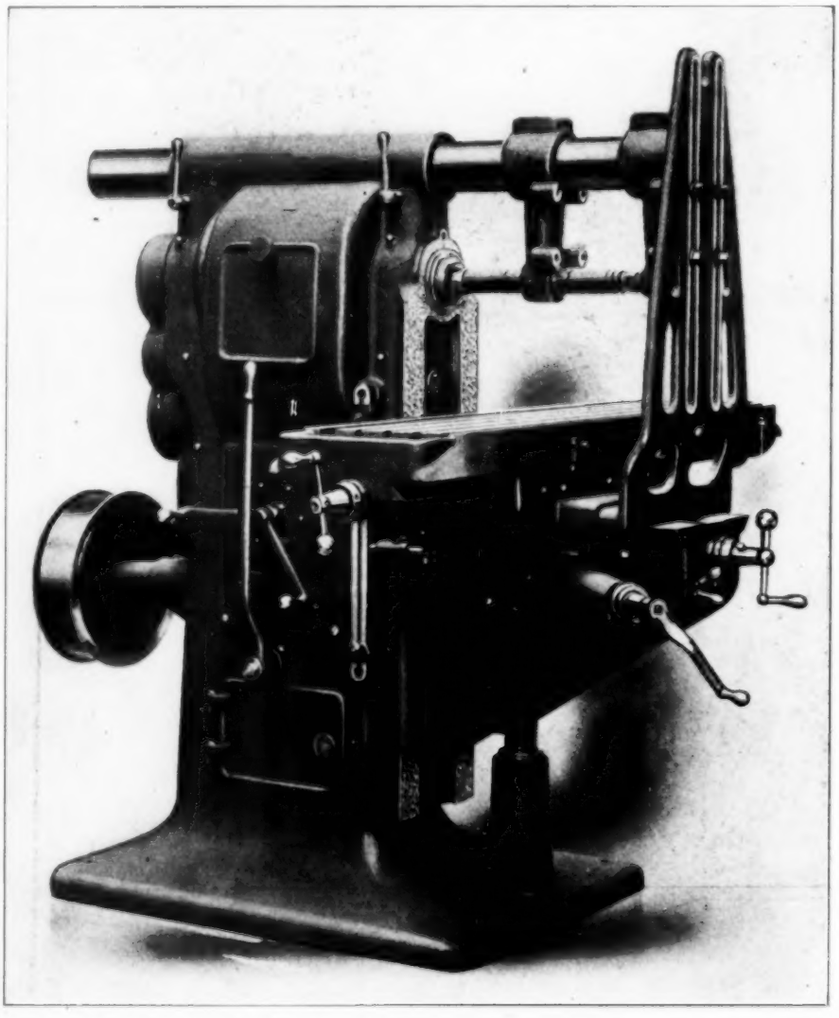

FIG. 7. PLAIN MILLING MACHINE WITH CONSTANT-SPEED DRIVE.

The Automobile Club's Dynamometer

An Apparatus Which Gives Speed, Draw-bar Pull, Horse-power, Grade-climbing Ability, Etc., of an Automobile at a Glance

EDITORIAL CORRESPONDENCE

An important advance has been made by the Automobile Club of America, New York, in the construction and installation of a unique machine which will determine instantly the speed in miles per hour and feet per second, draw-bar pull or tractive effort, horse-power, grade-climbing ability, and power of the brakes of any automobile which is placed upon it.

The dynamometer, besides being the most complete apparatus ever built for testing automobiles, makes it unnecessary to get special permission to speed machines in making a running test, will eliminate all danger of road accidents during tests and give the results more quickly and accurately than in any other way. It is of the greatest value to the intending purchaser of an automobile, and to the manufacturer who wishes to close a sale. The purchaser can now say to the manufacturer: "I want a car of such horse-power, such speed, such draw-bar pull and that will climb such a grade. If this machine is shown by the club dynamometer to be what I want, I will buy it."

The dynamometer, with the club scales for weighing cars, should provide conclusive answers to all automobile conundrums.

The word "dynamo-meter" is usually applied to a simple apparatus, either a spring balance for weighing the draw-bar pull required to draw a carriage or railroad car at a given speed, or a power-absorbing device for consuming the power given off by an engine under trial. There are also numerous other forms. To obtain results it is always necessary to make calculations from the readings observed. The apparatus at the club is a machine upon which an automobile of any kind may be placed and operated, and the result read at once in speed, pull and horse-power. It is therefore not only a dynamometer in the usual sense, but a calculator of the readings obtained by a dynamometer.

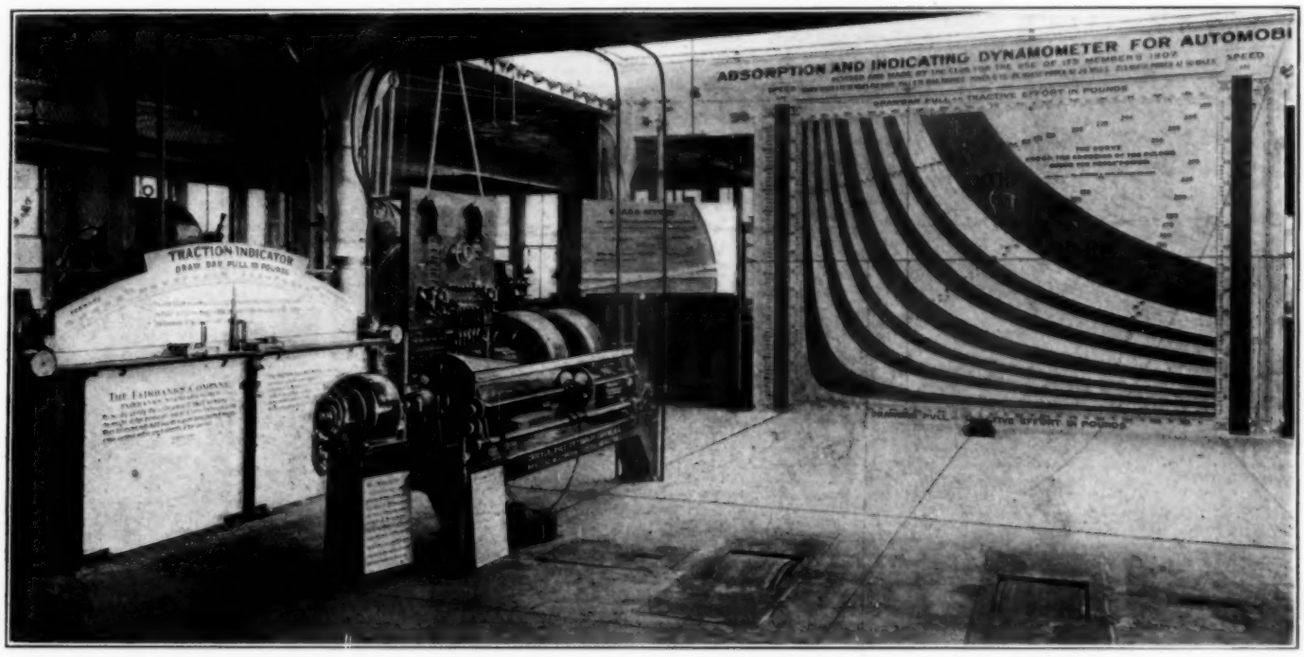

FIG. 1. APPARATUS ABOVE THE FLOOR

The club dynamometer is a moving track upon which cars can be fully tried out while remaining stationary and under observation. In 1904 Dr. Schuyler Skaats Wheeler, first vice-president of the Automobile Club, was requested by the club to invent, design and build a machine for determining accurately the performance of cars of all kinds. The present machine is, therefore, the result of several years' attention to this problem on the part of Dr. Wheeler.

It is an assemblage of power-absorbing and measuring instruments and a large power chart with automatically operated pointers. It carries the problem of power measurement, integration and automatic recording of the final results, much farther than has hitherto been attempted. It absorbs and measures the power so that, at a glance, the speed, tractive effort and horse-power can be clearly seen and read at each instant. The measurements show the power delivered at the ground by the wheels of the automobile. This includes every element in the operation of the automobile, and, therefore, shows the net power that is available for driving the car.

Instead of traveling along as on a road the car is held stationary by cables upon the floor with its driving wheels resting upon two large drums which reach up through the floor and which the motor of the automobile causes to revolve. The revolution of the drums is resisted by a huge pendulum hanging below the floor, and attached to the drum shaft, not rigidly, but through a device furnishing a degree of friction which can be varied, as shown by Fig. 2.

The pendulum, in consequence, swings out from the vertical a distance exactly proportional to the pull exerted by the car upon the drums. The amount of this pull, or "tractive effort," is indicated by a pointer attached to the pendulum and reaching above the floor, as shown at the traction indicator to the extreme length of Fig. 1. This weighing apparatus or pendulum has been tested and certified

correct by the Fairbanks company. The indications given by the pendulum are transferred to a ruler traveling across the face of a large chart, shown to the right of Fig. 1, by a wire cable moved by a small motor, in such manner that with each varying position of the pendulum pointer, the cable is moved to correspond to its new position and this reading is proved by that on the traction indicator.

The more difficult operation of measuring accurately the speed of the car, by moving another ruler vertically across the large chart, is accomplished by special apparatus of some novelty.

A cone is revolved by an electric motor at absolutely constant speed. To verify this speed, a bell, attached to the cone shaft, rings at each 100 revolutions, or at intervals of 30 seconds. A wheel or roller, driven by the automobile and

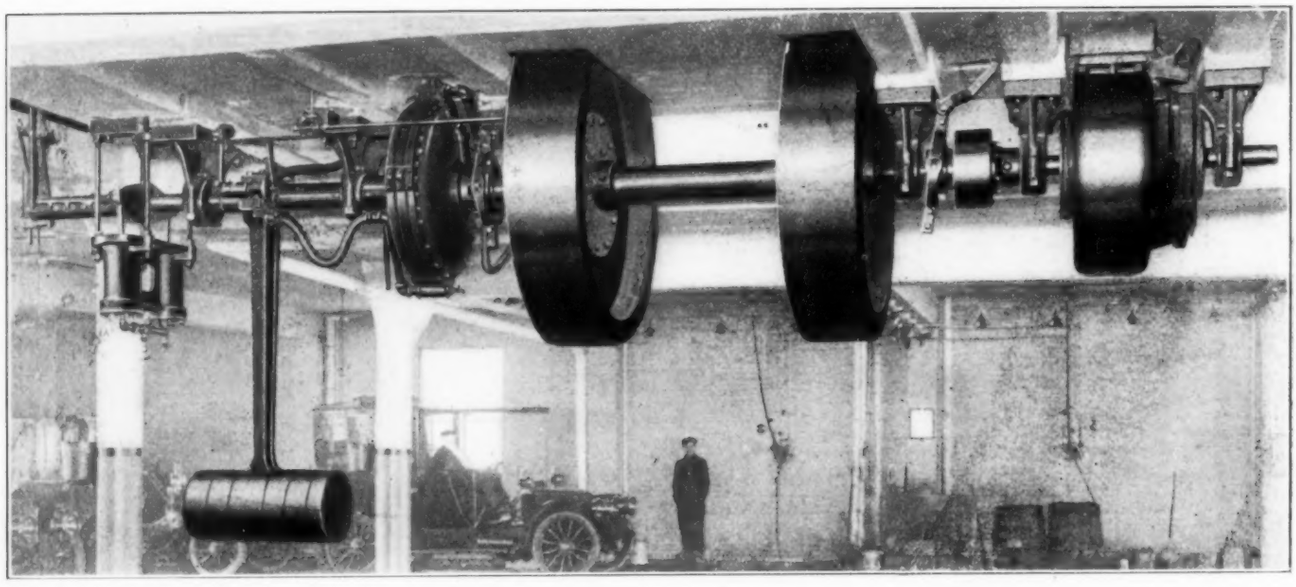

FIG. 2. APPARATUS BELOW THE FLOOR

therefore revolving slowly or fast to correspond, rolls upon the surface of the cone and is pulled, by an independent motor, back and forth between the small and large ends of the cone until it finds the point where it does not slip because that portion of the cone presents the same speed as the roller. This apparatus is shown by the machine in front of the speed indicator in Fig. 1. This longitudinal adjustment of the roller is transmitted by a wire cable to the speed ruler which moves up and down on the large chart, and the power required for moving the ruler is thus made independent of the automobile. In other words, none of the power of the automobile is used in operating the indicators on the chart. The method of speed measurement employed, based upon one element running at a constant speed like a clock, that can be verified, insures great accuracy. The roller, driven by the car if running at 60 miles per hour, must be drawn to a position near the large end of the cone in order to run with the cone. Whereas, if the car drives the roller at only five miles per hour, it must be drawn to a position near the small end of the cone. A system of electric contacts is arranged with a motor to shift the roller automatically until it finds the point where it will roll on the cone without slipping.

The speed and power rulers are thus moved across the chart in different directions, automatically, to correspond with the speed and the tractive effort or pull that the dynamometer shows the car is making, and from the point where these intersect is easily read the horse-power which has been plotted in curves as shown on the chart.

The chart is in heroic scale and can be read easily by the driver of the car. The speed of the car may be read from the chart in either of the popular ways of stating it: Miles per hour, minutes per mile, kilometers, etc., by means of the several different scales provided.

All of the measuring apparatus is made reversible, so that when running backward the performance of the car may be measured.

As a secondary apparatus, a grade meter is provided, as shown to the left of the big chart in Fig. 1, which is operated by the pendulum indicator of the dynamometer. To use the grade meter the clamp is set upon the sliding scale at the point representing the weight of the car. The moving lever then assumes at each moment the angle of inclination of the grade the car would climb if there were no wind resistance, slipping, etc., with the effort that the car is then making.

To observe an automobile coasting down hill, either forward or backward, it is necessary merely to start the electric motor, shown to the extreme right of Fig. 2, on the shaft carrying the two large drums upon which the driving wheels of the automobile rest. The brakes may then be tested and the wheels or gears or engine may be run free (not run by the power of the automobile) and the relative friction loss in the principle of the automobile may be ascertained.

By placing the front wheels of the car on the drums and driving these with the electric motor the speedometer can be tested as to its accuracy by comparing it with the results obtained on the chart.

Some of the tests made on this apparatus showed that one automobile which claimed to have an engine of 35-40 horsepower could not deliver over 21 horsepower to the rear wheels, while many others give similar results and the installation of an apparatus like this that will give the actual results at a slight cost may result in the manufacturers being more conservative in their claims as to horse-power, grades the cars will climb and speeds.

E. F. L.

Want Advertisements

Rate 25 cents a line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E.G.Smith Co., Columbia, Pa.

If you use small gears in large quantities, write Berry and Parker, Erie, Pa.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACHINIST.

Hand power bending tools, labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Light, fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Special machinery designed and built; duplicate parts, tools, jigs and dies. The Wade Machinery Co., 133 Oliver St., Boston.

Special machinery accurately built. Screw machine and turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

Mechanics write for our special offer of how to get a set of wrenches free. Bullard Automatic Wrench Co., Providence, R. I.

Special machinery designed and built; inventions, novelties, ideas, etc. developed. Albert Pott, M. E., 63 Bank St., Waterbury, Ct.

Special machines designed and built; duplicate parts, model or experimental work. Mantle, Park ave. and 129th St., New York.

Automatic machinery designed, ideas developed, work done by the hour at your place or mine. "G. C. H.," Box 751, AMER. MACH.

Automatic machinery designed; special purpose machines; working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia, Pa.

Do not trouble setting the tail stock over on your lathe, get a Cincinnati center for tapers. Max C. Zange, 2827 Sidney Ave., Cincinnati, O.

Designer of automatic and special machinery; mechanical drawings of any kind made. John G. Wittum, M. E., 93 Sherman Ave., Newark, N. J.

Wanted—To correspond with individual or firm with a view to establishing agency for Electric Cranes in New York and Philadelphia territory. Box 730, AMER. MACHINIST.

Have you any copies of December 12 and 19 issues of the AMERICAN MACHINIST? We will give fifteen cents for every copy that we can get. AMERICAN MACHINIST, 505 Pearl St., New York.

Wanted—New or second hand power shear, preferably of Alligator type, for cutting heavy copper scrap, coils of wire, etc. Address with particulars, price, etc., P. O. Box No. 2125, New York City.

A mechanical engineer wishes to put some money in and assist in the management of the factory and sales of a small manufacturing business located in or near Philadelphia. Box 767, AMERICAN MACHINIST.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACHINIST.

Machinery built to order and by contract; special parts made; gear cutting, automobile and pattern work, punch press and screw machine work, tools, dies, etc. Blair Tool and Machine Works, West and Morris Sts., New York City.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

To the American manufacturers who contemplate getting Canadian business for their wares will say that we have a well equipped factory for the building of tools, special machinery and the goods for this market; our experience is and has been on the finest of work. Box 773, AMERICAN MACHINIST.

The annual meeting of the stockholders of the Hill Publishing Company, for the election of directors for the ensuing year and for the transaction of such other business as may properly come before the meeting, will be held at the office of the company, in the Hallenbeck building, 497-505 Pearl street, Borough of Manhattan, New York City, N. Y., on Tuesday, January 28, 1908, at 12 o'clock noon.
Dated New York City, December 17th, 1907. Robert McKean, Secretary.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CANADA

Position wanted by a jobbing brass molder willing to go to any part of the United States; can handle any kind of metal, heavy or light castings; am a strictly sober and steady worker. Address "W," AMER. MACH.

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Assistant superintendent manufacturing plant 3 years; 5 years' previous experience in machine shop and drafting room; 32 years old; Yale graduate; member of A. S. M. E.; location, in or near Chicago. Box 732, AMERICAN MACHINIST.

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Is your production slow and costly? Try another superintendent more up to date, expert mechanic, executive, good organizer and systematizer; wide awake with long and varied experience as superintendent; light or medium manufacturing preferred. Address "Expert," AMERICAN MACHINIST.

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First class designer on tools and automatic machinery for medium and small work; 12 years in shop and office; practical, up to date; A-1 references; now in charge; wants to change. Box 765, AMERICAN MACHINIST.

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Ambitious man, 25, with 5 years' shop experience, 4 years as draftsman; fair technical education; wishes position with advancement. Box 761, AMERICAN MACHINIST.

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Toolmaker wishes position. Box 778, AMERICAN MACHINIST.

Mechanical draftsman wishes position. Address Box 776, AMERICAN MACHINIST.

Draftsman, toolmaker, ingenious, inventive ability, wishes position as foreman. Box 777, AMERICAN MACHINIST.

Draftsman; 25 years of age with shop experience wishes position; Greater New York preferred. Box 770, AMERICAN MACHINIST.

Mechanical engineer; college graduate; one year shop, four years' drafting experience, wants position. Box 759, AMER. MACHINIST.

Mechanical engineer, college graduate; 12 years' shop and designing experience; A-1 references; wants position. Box 783, AM. M.

Position by expert operator on semi-auto. turret lathe; will take charge or demonstrate; can devise tool equipment. Box 764, AM. M.

Draftsman with 9 years' shop experience, and for six years designing high class tools, dies and automatic machinery wants position. Box 784, AMERICAN MACHINIST.

Designer and draftsman on different classes of machinery; technical graduate; 6 years' shop and 5 years' drawing office experience. Box 771, AMERICAN MACHINIST.

Mechanical draftsman; 25; American; wishes position; 2 years' shop, 5 years' board experience; familiar with marine, automatic and general machine work. Box 782, AM. M.

Technical graduate with factory experience as foreman carpenter, pattern maker, and general construction work; references; wants position. Box 763, AMER. MACHINIST.

Engineer-designer, expert on electric hoists, cranes, tram-rail systems, etc.; large experience in office and on road as engineer-salesman; open for position in office or on road; first class references; good machine designer. Box 772, AMERICAN MACHINIST.

Wanted—Position by foundry foreman; young, strictly temperate in habits, well up in cupola practice and mixing iron and brass; thoroughly understands equipping and organizing new foundries; can furnish best of references; willing to go anywhere. Box 774, AMERICAN MACHINIST.

OHIO

Energetic wood pattern maker; 26; wants work anywhere. "Hargreves," 1528 Prospect Ave., Cleveland, O.

PENNSYLVANIA

Machine shop foreman, experienced toolmaker, desires change; shop or department; Philadelphia or vicinity. Box 780, AM. M.

Young man; technical graduate, with six years' shop and drafting room experience, wishes position with manufacturing firm to learn salesmanship. Box 766, AMER. MACH.

WISCONSIN

General foreman or superintendent; 31; practical mechanic successful in producing first class work at satisfactory cost; am an organizer of best shop methods; am now employed as superintendent; best of references. Box 754, AMERICAN MACHINIST.

FOREIGN

Position wanted in England to represent American firm or develop manufacturing, by mechanical engineer; age 35; large experience in designing special machinery and tools for manufacturing typewriters and typesetting machines; at present assistant manufacturing superintendent in large modern lock factory. Box 781, AMERICAN MACHINIST.

Help Wanted

Classification indicates present address of advertiser, nothing else.

LOUISIANA

Wanted—By a southern jobbing machinery house, controlling first-class agencies; a first class machine tool salesman. Box 775, AMERICAN MACHINIST.

MASSACHUSETTS

Mechanical designer; a first-class mechanical designer with large experience in designing high-speed steam engines wanted for permanent position in New England States; state age, education, experience in detail and salary expected; only detailed applications will be considered. Box 749, AMER. MACH.

NEW YORK

Foreman wanted for screw machine department; state experience, qualifications and salary expected; good opportunity for permanent connection for a capable man. Box 779, AMERICAN MACHINIST.

Patternmaker for steady shop in connection with jobbing iron foundry, handling all kinds of work; good, permanent position for sober, competent mechanic; state age, experience and wages wanted at start. Address "Open Shop Foundry," Room 1708, 141 Broadway, New York City.

Wanted—A mechanical draftsman familiar with mixing and kneading machinery for bread doughs, chemicals, paint, etc.; to a man thoroughly conversant with this line of machinery, we can offer a good position; state age, experience, if married or single, and salary expected. Address "Mixers," AM. MACH.

Wanted—Draftsman for leading place in drawing office of engineering and manufacturing concern; preferably one who has had mechanical training and conversant with shop practice; to inspect work in course of execution and detect irrational methods; good salary will be paid to man who can demonstrate ability; answer giving experience, age, etc. Box 762, AMERICAN MACHINIST.

Superintendent with experience and good executive ability, capable of taking full charge of the manufacturing end of a modern plant employing 250 men in the manufacture of a line of A-1 machine tools; location a pleasant town of 10,000 inhabitants, moderate rents, etc.; this is a good opportunity for the right man; state age, experience and salary expected, with references. Address "Manufacturer," AMERICAN MACHINIST.

OHIO

Top notch foundry superintendent wanted at once for new machine-molding gray iron foundry; the various buildings and equipment just being completed; strictly up-to-date including continuous pouring; applicant must be temperate in habits, of good character, aggressive, and above all, a good executive; full knowledge of molding machines and best application of patterns thereto absolutely necessary; give full particulars, references, where employed at present, and state salary required; all communications treated confidentially; no cheap man need apply. Address The Cincinnati Milling Machine Co., Cincinnati, Ohio.

PENNSYLVANIA

Wanted—A first-class machinist for universal milling machine work; state experience. Stoever Foundry and Manufacturing Company, Myerstown, Penn.

Toolmaker, A-1 practical mechanic, able to handle help, up to date and a hustler; a man with experience in large bed factory preferred. Box 768, AMERICAN MACHINIST.

VERMONT

Want to get in touch with a number of cost accountants, time, cost and factory clerks; give complete record. Address P. O. Box 713, Windsor, Vt.

WISCONSIN

A man with some technical training capable of taking charge of follow up system and developing into a first-class salesman; position difficult, but offers excellent opportunity; give references and salary expected. Box 769, AMERICAN MACHINIST.

FOREIGN

Wanted—First-class designer and draftsman from United States of America for modern tool and machinery; must be able to talk Norwegian or Swedish, and be well informed about modern tool building. "Progress," Verktoimaskinfabrik, Christiania, Norway.

Wanted for responsible position in Berlin, a first-class, thorough engineer, with large experience in machine tool works; applicant must also have some knowledge of building dynamos in large electrical works; give full information as to ability, past experience, references, recommendations, salary, when ready to accept position to Allgemeine Elektricitäts Gesellschaft, Berlin, Abteilung DJ, Brunnenstrasse 107a.

For Sale

For Sale—Foundry, wood and iron machine shop; all equipped. Box 74, Albion, N. Y.

For Sale—Back copies American Machinist. J. Beasley, Metropolitan Bldg., Orange, N. J.

For Sale—Ten volume library, covering completely the work of the engineer and machinist; good as new; cost $50; will sell for $15. Address "T. M. T.," Box 425, Chicago.

For Sale—Cyclopedia for modern shop practice, four volumes; bound in green morocco leather. Practically new; cost $18; will sell for $6. Address "L. N. O.," Box 425, Chicago, Ill.

Copyrights, drawings and cuts of computers designed by the late William Cox covering gas flow, strength of rectangular beams, strength of gears, strength of belting, discharge of water in pipe, train resistance and others for sale at an exceptionally low price. Address Mrs. Wm. Cox, 971 Summit Ave., New York City.

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Aftercoolers, Air

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Arbor Presses

Barnes Co., W. F. & John, Rockford, Ill.
Marshall & Huschart Machinery Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
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Arbors

Cleveland Twist Drill Co., Cleveland, O.
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Bowsher Co., N. P., South Bend, Ind.

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Cleveland Wire Spring Co., Cleveland, O.
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Beaman & Smith Co., Prov., R. I.
Cleveland Twist Drill Co., Cleveland, O.
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Bearings, Ball and Roller

Boston Gear Works, Norton Downs, Mass.
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Cling-Surface Mfg. Co., Buffalo, N. Y.
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Bristol Co., Waterbury, Conn.

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Birdsboro Steel Foundry & Mach. Co., Birdsboro, Pa.

Belt Shifters

The L. & D. Co., Boston, Mass.

Belting, Leather

Rhoads & Sons, J. E., Phila., Pa.
Schieren & Co., Chas. A., New York.
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Whitman & Barnes Mfg. Co., Chicago, Ill.

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Manufacturing Equipment & Engineering Co., Boston, Mass.

Bending Machinery, Hydraulic

Niles-Bement-Pond Co., New York.
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Bending Machinery, Plate

Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Toledo Machine & Tool Co., Toledo, Ohio.
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Bending Machinery, Power

Bethlehem Foundry and Machine Co., South Bethlehem, Pa.
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Niles-Bement-Pond Co., New York.
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Bending Tools, Hand

Estep & Dolan, Sandwich, Ill.
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Whitman & Barnes Mfg. Co., Chicago, Ill.

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Nicholson & Co., W. H., Wilkes-Barre, Pa.
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American Gas Furnace Co., New York.
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Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

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Cleveland Cap Screw Co., Cleveland, O.
National-Acme Mfg. Co., Cleveland, O.

Bone for Case Hardening

Rogers & Hubbard Co., Middletown, Conn.

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American School of Correspondence, Chicago, Ill.
Henley Pub. Co., N. W., New York.
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Piers, Frank, Phila., Pa.
Sames, Chas. M., Jersey City, N. J.

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Burke Electric Co., Erie, Pa.
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Crocker - Wheeler Co., Ampere, N. J.
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Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
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Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

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Beaman & Smith Co., Prov., R. I.
Betts Mach. Co., Wilmington, Del.
Binsse Mach. Co., Newark, N. J.
Boynton & Plummer, Worcester, Mass.
Detrick & Harvey Mach. Co., Wilmington, Del.
Fitchburg Machine Works, Fitchburg, Mass.
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Lucas Mach. Tool Co., Cleveland, Ohio.
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Motch & Merryweather Machinery Co., Cleveland, O.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
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Vandyck Churchill Co., New York.
Whitcomb - Blaisdell Mach. Tool Co., Worcester, Mass.

Boring and Turning Mills, Vertical

American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Baush Mach. Tool Co., Springfield, Mass.
Betts Mach. Co., Wilmington, Del.
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Niles-Bement-Pond Co., New York.
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Sellers & Co., Inc., Wm., Philadelphia, Pa.
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Armstrong Bros. Tool Co., Chicago, Ill.

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Cleveland Wire Spring Co., Cleveland, O.
Lyon Metallic Mfg. Co., Aurora, Ill.

Box Tools

Bardons & Oliver, Cleveland, O.

Brackets, Lamp

Standard Welding Co., Cleveland, Ohio.

Brazing

Industrial Oxygen Co., New York.
Reinforced Brazing and Machine Co., Pittsburg, Pa.

Broaching Machines

Harrington, Son & Co., Edwin, Philadelphia, Pa.
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Bulldozers

National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.

Cabinets, Tool

Armstrong Bros. Tool Co., Chicago, Ill.
Hammacher, Schlemmer & Co., New York.
Lyon Metallic Mfg. Co., Aurora, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Calipers

Athol Mach. Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Sawyer Tool Mfg. Co., Fitchburg, Mass.
Slocomb Co., J. T., Providence, R. I.
Starrett Co., L. S., Athol, Mass.

Cams

Bilgram, Hugo, Phila., Pa.
Boston Gear Works, Norfolk Downs, Mass.

Carborundum

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Carborundum Paper and Cloth

Carborundum Co., Niagara Falls, N. Y.

Case-Hardening

Rogers & Hubbard Co., Middletown, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

Cast Iron Brazing

Industrial Oxygen Co., New York.
Reinforced Brazing & Mach. Co., Pittsburg, Pa.

Castings, Brass and Bronze

Lumen Bearing Co., Buffalo, N. Y.
Rowell Co., W. G., Bridgeport, Ct.

Castings, Die Molded

Franklin Mfg. Co., H. H., Syracuse, N. Y.

Castings, Iron

Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Carr & Co., Stuart R., Baltimore, Md.
Cell Drier Machine Co., Taunton, Mass.
Farrel Fdry. & Mach. Co., Ansonia, Conn.

Castings, Steel

Bethlehem Steel Co., So. Bethlehem, Pa.
Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Cammel, Laird & Co., New York.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Witteman & Co., A. P., Phila., Pa.

Cement, Cast Steel

Clark Cast Steel Cement Co., Shelton, Conn.

Centering Machines
Hendey Mach. Co., Torrington, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Whiton Mach. Co., D. E., New London, Conn.

Centers, Planer
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Woodward & Powell Planer Co., Worcester, Mass.

Chains, Driving
Baldwin Chain & Mfg. Co., Worcester, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Link-Belt Co., Philadelphia, Pa.
Morse Chain Co., Ithaca, N. Y.
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Hammacher, Schlemmer & Co., New York.
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Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
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Chucks, Drill
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Brown & Co., R. H., New Haven, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Cushman Chuck Co., Hartford, Conn.
Grönkvist Drill Chuck Co., Jersey City, N. J.
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Trump Bros. Mach. Co., Wilmington, Del.
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Chucks, Planer
Niles-Bement-Pond Co., New York.
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Chucks, Split
Hardinge Bros., Chicago, Ill.
Rivett Lathe Mfg. Co., Boston, Mass.

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Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps
Billings & Spencer Co., Hartford, Conn.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Le Count, Wm. G., So. Norwalk, Conn.
Starrett Co., L. S., Athol, Mass.
Tudor Mfg. Co., Taunton, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

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Caldwell, Son & Co., H. W., Chicago, Ill.
Cowanesque Valley Iron Wks., Cowanesque, Pa.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newton Centre, Mass.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.

Clutches, Magnetic
Electric Controller & Supply Co., Cleveland, Ohio.

Coal Handling Machinery
Link-Belt Co., Philadelphia, Pa.

Coils
Standard Welding Co., Cleveland, Ohio.

Collets and Attachments, Spring
Adjustable Collet Co., Cleveland, Ohio.

Compound, Core
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.

Compound, Pipe Joint
Dixon Crucible Co., Joseph, Jersey City, N. J.

Compressors, Air
Blaisdell Machinery Co., Bradford, Pa.
Blanchard Mach. Co., Cambridge, Mass.
Bury Compressor Co., Erie, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compressor Works, New York.
Curtis & Co. Mfg.. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Sampson & Co., Geo. H., Boston, Mass.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas
Blaisdell Machinery Co., Bradford, Pa.

Conduit, Interior
Sprague Electric Co., New York.

Cones, Friction
Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps
Bethlehem Steel Co., So. Bethlehem, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work
Blanchard Mach. Co., Cambridge, Mass.
Cell Drier Machine Co., Taunton, Mass.
Ingle Machine Co., Rochester, N. Y.
Manville Bros. Co., Waterbury, Conn.
Merritt, Jos., Hartford, Conn.
Turner Mach. Co., Danbury, Ct.

Controllers and Starters, Electric Motor
Case Mfg. Co., Columbus, O.
Crocker - Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic
Link-Belt Co., Philadelphia, Pa.

Coping Machines
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.

Corundum
See Grinding Wheels.

Cotters
Adjustable Collet Co., Cleveland, Ohio.
Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores
Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.

Counters, Machinery
Veeder Mfg. Co., Hartford, Conn.

Countershafts
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Builders Iron Foundry, Providence, R. I.
Coates Clipper Mfg. Co., Worcester, Mass.
Evans Friction Cone Co., Newton Centre, Mass.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Manning, Maxwell & Moore, Inc., New York.
Mossberg Wrench Co., Central Falls, R. I.
Norton Grinding Co., Worcester, Mass.
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction
Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing
Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counting and Printing Wheels
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Couplers, Hose
Ingersoll-Rand Co., New York.

Couplings, Shaft
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Caldwell & Son Co., H. W., Chicago, Ill.
Davis Machine Co., W. P., Rochester, N. Y.
Link-Belt Co., Philadelphia, Pa.
Manning, Maxwell & Moore, Inc., New York.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.

Cranes
Brown Hoisting Mach. Co., Cleveland, O.
Case Mfg. Co., Columbus, O.
Chicago Pneumatic Tool Co., Chicago, Ill.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.

Cranes—*Continued.*
General Pneumatic Tool Co., Montour Falls, N. Y.
Manning, Maxwell & Moore, Inc., New York.
Maris Bros., Philadelphia, Pa.
Moore Co., Franklin, Winsted, Ct.
Nicholls, Wm. S., New York.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co., New York.

Crank Pin Turning Machines
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Crank Shafts
Bethlehem Steel Co., So. Bethlehem, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles
Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Crushers
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

Cupolas, and Ladles, Foundry
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.

Cups and Covers, Oil
Bay State Stamping Works, Worcester, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
Winkley Co., Detroit, Mich.

Cups, Grease
Lunkenheimer Co., Cincinnati, O.

Cutters, Milling
Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Hardinge Bros., Chicago, Ill.
Harrison & Knight Mfg. Co., Newark, N. J.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Nash Company, Geo., New York.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines
Armstrong Bros. Tool Co., Chicago, Ill.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Davis Machine Co., W. P., Rochester, N. Y.
Hill, Clarke & Co., Inc., Boston, Mass.
Hurlbut-Rogers Mach. Co., South Sudbury, Mass.
Manning, Maxwell & Moore, Inc., New York.
Newton Mach. Tool Wks., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Schmitz, August, Dusseldorf, Germany.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.

Machine Department

Chain Department

Miscellaneous Department

We are now well settled in our New Factory and

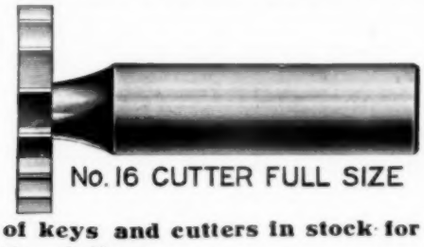
Ready to Show Results

Prompt Delivery and Constant Improvement in Quality

In our effort to possess the Finest Chain Plant in existence and to maintain the highest degree of Accuracy, Efficiency and Finish we are going to the very limit.

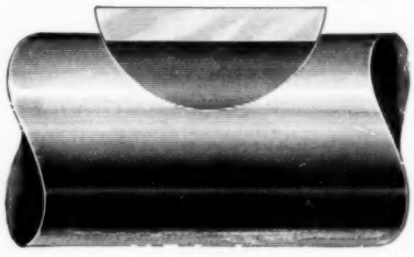
We will now make all sizes of Roller and Bushing Chains for which there is a reasonable demand.

"WHITNEY" MACHINE KEYS and KEY-SEAT CUTTERS
(For the Woodruff Patent System of Keying)

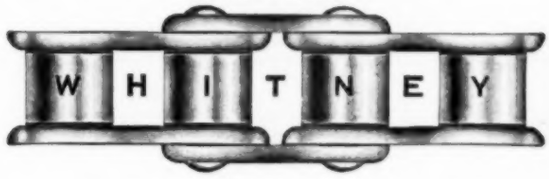


No. 16 CUTTER FULL SIZE

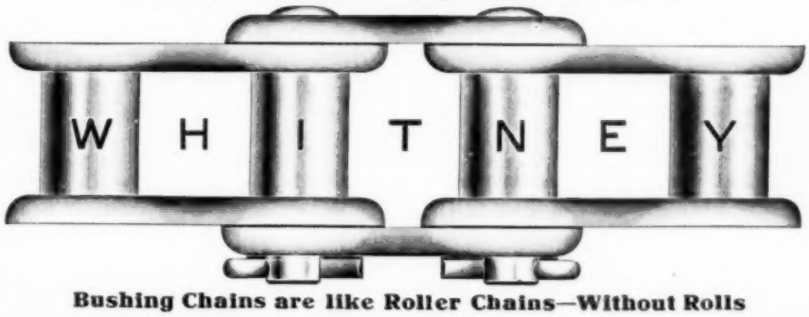
We carry 95 regular Sizes of keys and cutters in stock for immediate delivery.



Roller Chain



"Whitney" Detachable Bushing Chain—Patented



Bushing Chains are like Roller Chains—Without Rolls

The Whitney Mfg. Co.

Hartford, Conn.

Cutting-off Tools—*Continued.*
Cleveland Twist Drill Co., Cleveland, O.
Fitchburg Machine Works, Fitchburg, Mass.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.
Western Tool & Mfg. Co., Springfield, O.

Diamond Tools
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Dickinson, Thos. L., New York.
Safety Emery Wheel Co., Springfield, O.

Dies, Sheet Metal
American Tube & Stamping Co., Bridgeport, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Consolidated Press and Tool Co., Hastings, Mich.
Ferracute Mach. Co., Bridgeton, N. J.
Globe Machine & Stamping Co., Cleveland, O.
Manville Bros. Co., Waterbury, Conn.
Risdon Tool Works, Waterbury, Conn.

Dies, Sub-Press
Risdon Tool Works, Waterbury, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Openi
Errington, F. A., New York.
Foote-Burt Co., Cleveland, O.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Machine Co., Springfield, Vt.
Pratt & Whitney Co., Hartford, Conn.

Dowel Pins
Winkley Co., Hartford, Conn.

Drawing Boards and Tables
Alteneder & Son, Theo., Philadelphia, Pa.
Artisans Guild, Benton Harbor, Mich.
Keuffel & Esser Co., New York.
Kolesch & Co., New York.
Mittineague Paper Co., Mittineague, Mass.

Drawing Materials
Alteneder & Son, Theo., Philadelphia, Pa.
Keuffel & Esser Co., New York.
Kolesch & Co., New York.
Mittineague Paper Co., Mittineague, Mass.
Technical Supply Co., Scranton, Pa.

Drafting Machines
Universal Drafting Mach. Co., Cleveland, O.

Drilling Machines, Bench
American Watch Tool Co., Waltham, Mass.
Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Ingersoll-Rand Co., New York.
Manning, Maxwell & Moore, Inc., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.
Rockford Drilling Mach. Co., Rockford, Ill.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
U. S. Electrical Tool Co., Cincinnati, O

Drilling Machines, Boiler
American Tool Works Co., Cin., O.
Bickford Drill & Tool Co., Cincinnati, O.
Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, O.
Ingersoll-Rand Co., New York.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Electric
Chicago Pneumatic Tool Co., Chicago, Ill.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.
Independent Pneumatic Tool Co., Chicago, Ill.

Drilling Machines, Multiple Spindle
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Flather Planer Co., Mark, Nashua, N. H.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Hardinge Bros., Chicago, Ill.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Newton Mach. Tool Works, Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.
Taylor & Fenn Co., Hartford, Ct.

Drilling Machines, Portable
Cincinnati Elec. Tool Co., Cin., O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Gem Mfg. Co., Pittsburg, Pa.
Hisey-Wolf Mach. Co., Cin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial
American Tool Wks. Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Foundry Co., Jno. B., Cincinnati, Ohio.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Wormer Mchy. Co., C. C., Detroit, Mich.

Drilling Machines, Turret
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.

Drilling Machines, Upright
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Boynton & Plummer, Worcester, Mass.
Cincinnati Mach. Tool Co. Cincinnati, O.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.

Drilling Machines, Upright—*Continued.*
Davis Machine Co., W. P., Rochester, N. Y.
Fosdick Mach. Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Hoefer Mfg. Co., Freeport, Ill.
Kern Machine Tool Co., Cincinnati, O.
Knight Machry. Co., W. B., St. Louis, Mo.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Mechanics Machine Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Taylor & Fenn Co., Hartford, Conn.
Vandyck Churchill Co., New York.
Whitney Mfg. Co., Hartford, Ct.
Wiley & Russell Mfg. Co., Greenfield, Mass.
Wormer Mchry. Co., C. C., Detroit, Mich.

Drills, Center
Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Hand
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drills, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compressor Works, New York.

Drills, Rail
Foote-Burt Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

Drills, Ratchet
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Cleveland Twist Drill Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cin., O.
Manning, Maxwell & Moore, Inc,, New York.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.

Drills, Rock
Ingersoll-Rand Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.

Drill Speeder
Graham Mfg. Co., Providence, R. I.

Drying Apparatus
Sturtevant Co., B. F., Hyde Park, Mass.

Dynamos
Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker - Wheeler Co., Ampere, N. J.
Eck Dynamo & Motor Co., Belleville, N. J.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Roth Bros. & Co., Chicago, Ill.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincin., O.
Western Electric Co., Chicago, Ill.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrical Supplies
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Crocker - Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Roth Bros. & Co., Chicago, Ill.
Sprague Elec. Co., New York.
Triumph Electric Co., Cincin., O.
Wagner Elec. Mfg. Co., St. Louis, Mo.
Western Electric Co., Chicago, Ill.
Weston Elec. Instrument Co., Newark, N. J.
Westinghouse Elec. & Mfg. Co. Pittsburg, Pa.

Electrically Driven Tools and Machinery
American Tool Wks. Co., Cin., O.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Crescent Forgings Co., Oakmont, Pa.
Electric Controller & Supply Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cincin., O.
Manning, Maxwell & Moore, Inc., New York.
Roth Bros. & Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.
Western Electric Co., Chicago, Ill.

Elevators
Albro-Clem Elevator Co., Philadelphia, Pa.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Link-Belt Co., Philadelphia, Pa.
Morse, Williams & Co., Phila., Pa.

Emery Wheels
See Grinding Wheels.

Emery Wheel Dressers
American Emery Wheel Co., Providence, R. I.
Bay State Stamping Co., Worcester, Mass.
Desmond-Stephan Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Dickinson, Thos. L., New York.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vitrified Wheel Co., Westfield, Mass.
Wrigley Co., Thos., Chicago, Ill.

Enclosures, Tool-Room
Hart & Cooley Co., New Britain, Conn.
Merritt & Co., Philadelphia, Pa.

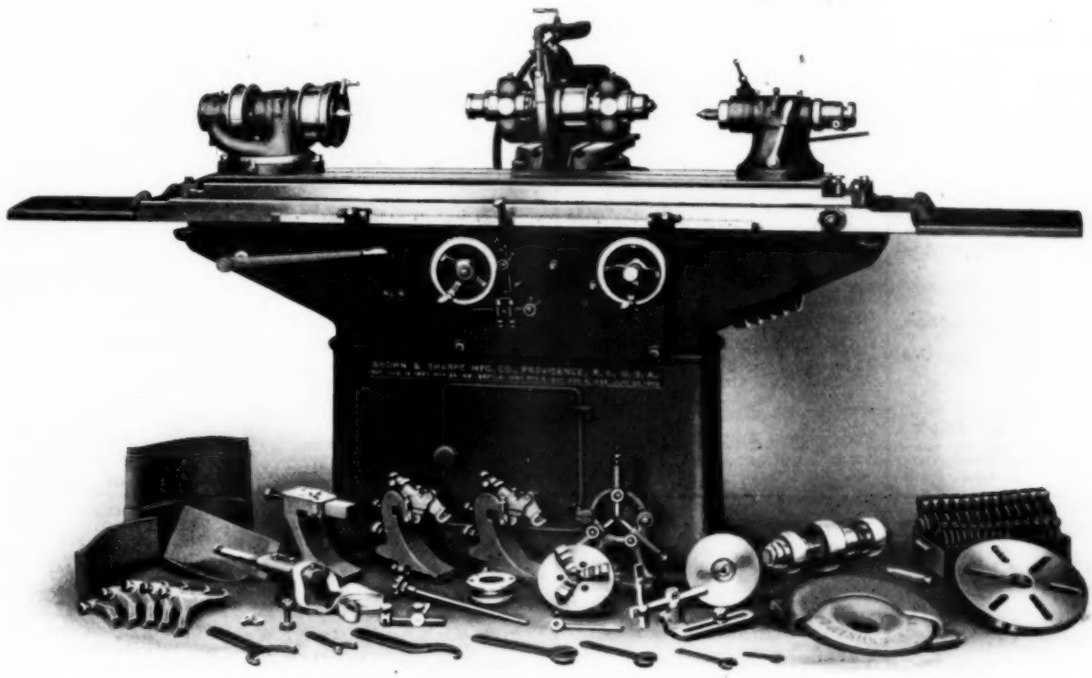
Engineering Appliances
Crosby Steam Gage & Valve Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.

Engineer, Consulting and Architect
Thompson, Hugh L., Waterbury, Conn.

Brown & Sharpe Mfg. Co.

Providence, R. I., U. S. A.

Not Only Is A B.&S. Grinding Machine Accurate When You Start It But Its Accuracy Is Durable



The importance of this point cannot be overestimated in that the Grinding Machine you want is the one that will wear well.

And nothing contributes so much toward the attainment of lasting accuracy as emphasis on Quality of Workmanship.

Sufficient weight that vibration may be eliminated as far as possible, each part in right relation to the whole, and correct alignments insisted upon, are all factors that establish accuracy as a permanent feature in B. & S. Grinding Machines.

A circular of any of the B. & S. Grinding Machines sent to any address.

Engineers, Mechanical and Electrical

Crocker - Wheeler Co., Ampere, N. J.
Merritt, Jos., Hartford, Conn.
Seaver, John W., Cleveland, O.

Engines, Gas and Gasolene

Automatic Mach. Co., Bridgeport, Conn.
Backus Water Motor Co., Newark, N. J.
Blaisdell Machinery Co., Bradford, Pa.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Olds Gas Power Co., Lansing, Mich.
Struthers-Wells Co., Warren, Pa.

Engines, Motor

Franklin Mfg. Co., H. H., Syracuse, N. Y.
Olds Gas Power Co., Lansing, Mich.
Ridgway Dynamo & Engine Co., Ridgway, Pa.

Engines, Steam

Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Engraving Machinery

Gorton Mach. Co., Geo., Racine, Wis.

Exhaust Heads

Sturtevant Co., B. F., Hyde Park, Mass.

Exhibition Machinery

Philadelphia Bourse, Phila., Pa.

Expanders, Tube

Nicholson & Co., W. H., Wilkes-Barre, Pa.

Factory Equipment

Lyon Metallic Mfg. Co., Aurora, Ill.
Mfg. Equipment & Eng. Co., Boston, Mass.

Fans, Electric

Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Fans, Exhaust

Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., Phila., Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Files and Rasps

American Swiss File & Tool Co., New York.
Barnett Co., G. & H., Phila., Pa.
Carver File Co., Philadelphia, Pa.
Hammacher, Schlemmer & Co., New York.
Nicholson File Co., Prov., R. I.
Reichheim & Co., E. P., New York.

Filler, Iron

Clark Cast Steel Cement Co., Shelton, Conn.
Felton, Sibley & Co., Phila., Pa.

Filing Machines

Cochrane-Bly Co., Rochester, N. Y.
Henry & Wright Mfg. Co., Hartford, Conn.

Flexible Shafts

Chicago Flexible Shaft Co., Chicago, Ill.
Coates Clipper Mfg. Co., Worcester, Mass.
Gem Mfg. Co., Pittsburg, Pa.
Manning, Maxwell & Moore, Inc., New York.

Forges

Boynton & Plummer, Worcester, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Burke Machy. Co., Cleveland, O.
Ingersoll-Rand Co., New York.
Miner & Peck Mfg. Co., New Haven, Conn.
National Machinery Co., Tiffin, O.

Forges—*Continued.*

Prentiss Tool & Supply Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Forgings, Drop

Bethlehem Steel Co., So. Bethlehem, Pa.
Billings & Spencer Co., Hartford, Conn.
Brown & Co., R. H., New Haven, Conn.
Crescent Forgings Co., Oakmont, Pa.
O. K. Tool Holder Co., Shelton, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

Forgings, Hydraulic

Bethlehem Steel Co., So. Bethlehem, Pa.

Forgings, Steel

Bethlehem Steel Co., So. Bethlehem, Pa.
Cammel, Laird & Co., New York.
Crescent Forgings Co., Oakmont, Pa.
Tindel-Morris Co., Eddystone, Pa.
Witteman & Co., A. P., Phila., Pa.

Foundry Furnishings

Adams Co., Dubuque, Iowa.
Goldschmidt Thermit Co., New York.
Ingersoll-Rand Co., New York.
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Furnaces, Annealing and Tempering

American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Tate, Jones & Co., Pittsburg, Pa.
Westmacott Gas Furnace Co., Providence, R. I.
Witteman & Co., A. P., Phila., Pa.

Furnaces, Enameling

American Gas Furnace Co., New York.

Furnaces, Gas

American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Obermayer Co., S., Cincinnati, O.
Westmacott Gas Furnace Co., Providence, R. I.

Furnaces, Melting

American Gas Furnace Co., New York.
Nash Company, Geo., New York.
Westmacott Gas Furnace Co., Providence, R. I.

Furnaces, Oil

Tate, Jones & Co., Pittsburg, Pa.

Furniture, Machine Shop

Hart & Cooley Co., New Britain, Conn.
Lyon Metallic Mfg. Co., Aurora, Ill.
Manufacturing Equip. & Engineering Co., Boston, Mass.
Merritt & Co., Philadelphia, Pa.
New Britain Mach. Co., New Britain, Conn.

Gages, Recording

Bristol Co., Waterbury, Conn.

Gages, Standard

Ames & Co., B. C., Waltham, Mass.
Athol Machine Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Grönkvist Drill Chuck Co., Jersey City, N. J.
Henry & Wright Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Wks., Jno. M., Gloucester City, N. J.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.

Gages, Standard—*Continued.*

Wyke & Co., J., East Boston, Mass.

Gages, Steam

Bristol Co., Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.

Gear Cutting Machinery

Adams Co., Dubuque, Iowa.
American Watch Tool Co., Waltham, Mass.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Bilgram, Hugo, Philadelphia, Pa.
Brown & Sharpe Mfg. Co., Providence, R. I.
Clough, R. M., Tolland, Conn.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Manning, Maxwell & Moore, Inc., New York.
Morse, Williams & Co., Phila., Pa.
Newton Machine Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Walcott & Wood Mach. Tool Co., Jackson, Mich.
Whiton Machine Co., D. E., New London, Conn.

Gear Testing Machinery

Gisholt Mach. Co., Madison, Wis.

Gears, Cut

Bilgram, Hugo, Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Caldwell & Son Co., H. W., Chicago, Ill.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Davis, Rodney, Philadelphia, Pa.
Earle Gear & Machine Co., Philadelphia, Pa.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fawcus Mach. Co., Pittsburg, Pa.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant Gear Wks., Boston, Mass.
Hardinge Bros., Chicago, Ill.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Horsburgh & Scott Co., The, Cleveland, Ohio.
Lea Equipment Co., New York.
Morse, Williams & Co., Phila., Pa.
Mutual Machine Co., Hartford, Conn.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Patterson, Gottfried & Hunter, Ltd., New York.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Wks., Cleveland, O.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.
Walcott & Wood Mach. Tool Co., Jackson, Mich.
Waterbury Gear Co., Waterbury, Conn.

Gears, Molded

Caldwell & Son Co., H. W., Chicago, Ill.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Horsburgh & Scott Co., Cleveland, Ohio.
Philadelphia Gear Works, Philadelphia, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.

Gears, Rawhide

Boston Gear Works, Norfolk Downs, Mass.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Earle Gear & Mach. Co., Philadelphia, Pa.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Grant Gear Works, Boston, Mass.
Horsburgh & Scott Co., Cleveland, O.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Works, Cleveland, O.

Gears, Worm

Albro-Clem Elevator Co., Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Horsburgh & Scott Co., Cleveland, Ohio.
Morse, Williams & Co., Phila., Pa.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.

Generating Sets

Burke Electric Co., Erie, Pa.
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York
Northern Electric Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Elec. Co., Cincinnati, O.

Generators, Gas

American Gas Furnace Co., New York.

Gibs

Standard Gauge Steel Co., Beaver Falls, Pa.

Graphite

Dixon Crucible Co., Jos., Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Grinders, Knife

American Wood Working Mchy. Co., Rochester, N. Y.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Safety Emery Wheel Co., Springfield, O.

Grinders, Center

Cincinnati Electrical Tool Co., Cincinnati, O.
Coates Clipper Mfg. Co., Worcester, Mass.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Gem Mfg. Co., Pittsburg, Pa.
Heald Mach Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cin., O.
Manning, Maxwell & Moore, Inc., New York.
Mueller Machine Tool Co., Cincinnati, O.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cin., O.

Grinders, Cutter

Bath Grinder Co., Inc., Fitchburg, Mass.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.
Crocker - Wheeler Co., Ampere, N. J.
Garvin Machine Co., New York.
Gould & Eberhardt, Newark, N. J.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll Milling Mach. Co., Rockford, Ill.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Norton Grinding Co., Worcester, Mass.

Crowning Pulleys On A Landis Grinding Machine

These five-step cast-iron cone pulleys with diameter of 2" for smallest step and increased to 6" diameter for largest step with face of 1 3/8" width were crowned to a perfect convex shape on a "LANDIS" Grinding Machine with actual grinding time of 8 minutes each. 1/32" metal removed.

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Grinders, Cutter—*Continued.*
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Rivett Dock Co., Boston, Mass.
U. S. Electrical Tool Co., Cincinnati, Ohio.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinders, Cylindrical
Bath Grinder Co., Inc., Fitchburg, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Heald Mach. Co., Worcester, Mass.
Landis Tool Co., Waynesboro, Pa.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Norton Grinding Co., Worcester, Mass.

Grinders, Disk
Bath Grinder Co., Inc., Fitchburg, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Diamond Machine Co., Providence, R. I.
Gardner Machine Co., Beloit, Wis.
Heald Mach. Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Safety Emery Wheel Co., Springfield, O.
Taylor & Fenn Co., Hartford, Ct.

Grinders, Drill
Heald Mach. Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
U. S. Electrical Tool Co., Cincinnati, Ohio.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinders, Internal
Bath Grinder Co., Inc., Fitchburg, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Greenfield Mach. Co., Greenfield, Mass.
Heald Mach. Co., Worcester, Mass.
Landis Tool Co., Waynesboro, Pa.
Manning, Maxwell & Moore, Inc., New York.
Rivett Lathe Mfg. Co., Boston, Mass.
U. S. Electrical Tool Co., Cincinnati, O.

Grinders, Portable
Cincinnati Eletcrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
U. S. Electrical Tool Co., Cin., O.

Grinders, Saw
Tindel-Morris Co., Eddystone, Pa.

Grinders, Surface
National Machine Co., Hartford, Conn.

Grinders, Tool
Armstrong Bros. Tool Co., Chicago, Ill.
Barnes Co., B. F., Rockford, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Bath Grinder Co., Inc., Fitchburg, Mass.
Blount Co., J. G., Everett, Mass.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Diamond Machine Co., Providence, R. I.
Gisholt Mach. Co., Madison, Wis.
Gould & Eberhardt, Newark, N. J.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Harrington, Son & Co., Edwin, Philadelphia, Pa.

Grinders, Tool—*Continued.*
Heald Mch. Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Landis Tool Co., Waynesboro, Pa.
Manning, Maxwell & Moore, Inc., New York.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Mummert, Wolf & Dixon Co., Hanover, Pa.
Niles-Bement-Pond Co., New York.
Norton Grinding Co., Worcester, Mass.
Rivett Lathe Mfg. Co., Boston, Mass.
Safety Emery Wheel Co., Springfield, O.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
U. S. Electrical Tool Co., Cin., O.
Vandyck Churchill Co., New York.
Vitrified Wheel Co., Westfield, Mass.
Whitney Mfg. Co., Hartford, Ct.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinding or Polishing Machinery
Abrasive Material Co., Philadelphia, Pa.
American Emery Wheel Co., Providence, R. I.
Barnes Co., W. F. & John, Rockford, Ill.
Bath Grinder Co., Inc., Fitchburg, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Blount Co., J. G., Everett, Mass.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Builders Iron Foundry, Providence, R. I.
Burke Machry Co., Cleveland, O.
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Crocker - Wheeler Co., Ampere, N. J.
Diamond Machine Co., Providence, R. I.
Gardner Mach. Co., Beloit, Mich.
Graham Mfg. Co., Providence, R. I.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Heald Mach. Co., Worcester, Mass
Hisey-Wolf Mach. Co., Cincin., O.
Landis Tool Co., Waynesboro, Pa.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
Monarch Emery & Cor. Wheel Co., Camden, N. J.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Norton Grinding Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Safety Emery Wheel Co., Springfield, O.
U. S. Electrical Tool Co., Cincinnati, O.
Vandyck Churchill Co., New York.
Vitrified Wheel Co., Westfield, Mass.

Grinding Wheels
Adams Co., Dubuque, Iowa.
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Carborundum Co., Niagara Falls, N. Y.
Diamond Machine Co., Providence, R. I.
Monarch Emery & Cor. Wheel Co., Camden, N. J.
Niles-Bement-Pond Co., New York.
Norton Co., Worcester, Mass.
Safety Emery Wheel Co., Springfield, O.
Vitrified Wheel Co., Westfield, Mass.
Whitney Mfg. Co., Hartford, Ct.

Grindstones and Frames
Athol Machine Co., Athol, Mass.
Cleveland Stone Co., The, Cleveland, O.
Niles-Bement-Pond Co., New York.
Norton Co., Worcester, Mass.

Gun Barrel Machinery
Diamond Machine Co., Povidence, R. I.
Pratt & Whitney Co., Hartford, Conn.
Reed Co., F. E., Worcester, Mass.

Hammers, Drop
Billings & Spencer Co., Hartford, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Bradley & Son, C. C., Syracuse, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Gould & Eberhardt, Newark, N. J.
Miner & Peck Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.

Hammers, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compressor Works, New York.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Sampson & Co., Geo. H., Boston, Mass.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Hammers, Power
Beaudry & Co., Inc., Boston, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.

Hammers, Steam
Bradley & Son, C. C., Syracuse, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Crescent Forgings Co., Oakmont, Pa.
Marshall & Huschart Machinery Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Handles, Machine Tool
Whitman & Barnes Mfg. Co., Chicago, Ill.

Hangers, Shafting
Link-Belt Co., Philadelphia, Pa.

Heaters, Feed Water
Sturtevant Co., B. F., Hyde Park, Mass.

Heating and Ventilating Apparatus
American Blower Co., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Heating Machines
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.

Hobbing Machines, Worm
Gould & Eberhardt, Newark, N. J.
Pratt & Whitney Co., Hartford, Conn.

Hoisting and Conveying Machinery
Brown Hoisting Machinery Co., Cleveland, O.
Case Mfg. Co., Columbus, O.
Caldwell & Son Co., H. W., Chicago, Ill.
Cleveland Crane & Car Co., Wickliffe, O.
Link-Belt Co., Philadelphia, Pa.
Manning, Maxwell & Moore, Inc., New York.
Moore Co., Franklin, Winsted, Ct.
Niles-Bement-Pond Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Yale & Towne Mfg. Co., New York.

Hoists, Electric
C & C Electric Co., New York.
Case Mfg. Co., Columbus, O.
Chicago Pneumatic Tool Co., Chicago, Ill.
Cleveland Crane & Car Co., Wickliffe, O.

Hoists, Electric—*Continued.*
Crocker - Wheeler Co., Ampere, N. J.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Electric Co., New York.
General Pneumatic Tool Co., Montour Falls, N. Y.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Sprague Electric Co., New York.
Yale & Towne Mfg. Co., New York.

Hoists, Hand
Case Mfg. Co., Columbus, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Moore Co., Franklin, Winsted, Ct.
Nicholls, Wm. S., New York.
Yale & Towne Mfg. Co., New York.

Hoists, Pneumatic
Chicago Flexible Shaft Co., Chicago, Ill.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Northern Engineering Works, Detroit, Mich.

Hones
Carborundum Co., Niagara Falls, N. Y.
Chicago Pneumatic Tool Co., Chicago, Ill.

Hose
Chicago Pneumatic Tool Co., Chicago, Ill.
Independent Pneumatic Tool Co., Chicago, Ill.
Rhoads & Son, J. E., Phila., Pa.
Sprague Electric Co., New York.

Igniters, Gas Engine
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Indicators, Speed
Warner Instrument Co., Beloit, Wis.

Indicators, Steam Engine
Crosby Steam Gage & Valve Co., Boston, Mass.

Indicators, Test
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Norton Grinding Co., Worcester, Mass.
Starrett Co., L. S., Athol, Mass.

Injectors
Desmond-Stephan Mfg. Co., Urbana, O.
Lunkenheimer Co., Cincinnati, O.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Inspection and Tests
Hunt Co., Robert W., Chicago, Ill.

Instruments, Electric
General Electric Co., New York.
Weston Elec. Instrument Co., Newark, N. J.

Iron Bar
Milton Mfg. Co., Milton, Pa.

Jacks, Hydraulic
Burroughs Co., Chas., Newark, N. J.
Watson-Stillman Co., New York.

Jacks, Planer
Armstrong Bros. Tool Co., Chicago, Ill.

Jacks, Lever and Screw
Watson-Stillman Co., New York.

Kettles, Soda
Brown & Sharpe Mfg. Co., Providence, R. I.
Gray & Prior Mach. Co., Hartford, Conn.
Mfg. Equip. & Engineering Co., E. Boston, Mass.

Key Seaters
Baker Bros., Toledo, O.
Barnes Co., B. F., Rockford, Ill.
Burr & Sons, John T., Brooklyn, N. Y.
Davis Machine Co., W. P., Rochester, N. Y.
Lapointe Mach. Tool Co., Hudson, Mass.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.